ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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MOTHERWELL, SCOTLAND. 7940
See half-page Advertisement page 98, Oct. 31.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
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Founded 1854 by SIR WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 7479

Electro Bleach and By-Products, Limited.

CAPITAL TO BE INCREASED TO £480,000.

COMPANY'S BRIGHT PROSPECTS.

An extraordinary general meeting of Electro Bleach and By-Products (Limited), was held in Manchester, Friday last.—Mr. H. J. MACKINDER, M.P. (chairman), presiding.

It was proposed to increase the capital of the company to £480,000 by the creating of 200,000 7 per cent. Participating Preference shares of £1 each, and a like number of Ordinary shares at 10s. each, while it was proposed to issue 80,000 shares of each class.

Mr. MACKINDER, in proposing the resolution, remarked that he was leaving the country very shortly for Russia on an important mission which had been entrusted to him by the Government. He hoped the meeting would agree to the resolution, and put the directors into a position to crown and complete the policy which they had been pursuing through fair weather and foul for the last six years. He did not intend resigning his chairmanship, as the Board had given him leave of absence for the few months to visit Russia. The directors, at a meeting that afternoon, had decided to declare an interim dividend on the Ordinary shares for the half-year ended June 30 of 7½d. per share, less income-tax at 6s. in the £1; being at the rate of 12½ per cent. per annum. Referring to the proposed increase of share capital, Mr. MACKINDER said he would dispose at once with one obvious criticism which might be levelled against one paragraph dealing with profits during the four succeeding years 1915, 1916, 1917, and 1918. In round figures the profits were £30,000, £50,000, £50,000, and £60,000. During these four successive years it might be said that these results were no guidance for the future, in that they referred to war profits. In 1915 the profits were made under adverse circumstances, in that owing to the war it was impossible to establish economies in manufacture which had been contemplated, and the same applied in a little less degree to the next year. Then during 1917 and 1918 they were a controlled firm, and were selling to the Government at fixed prices. Strictly speaking, they were selling at a censored profit, and over and above that they were never able to establish the economies intended.

HOW THE FUNDS WILL BE USED.

Mr. MACKINDER next dealt with the way the directors proposed to use any funds which resulted from the new issue. There were three items, and with regard to the £35,890 due to the Government, he dealt with that at the last ordinary general meeting. It was in respect of plant, buildings, and machinery erected for greater output, and the sum stated still remained to be paid to the Government. A certain amount had already been paid to the Government out of the general reserve fund of the company, and the feeling of the Board was that they would like to be masters in their own house, and it would be very undesirable that for a term of years any Government Department should have a claim upon the profits. With regard to the item of £10,000 over and above the plant, machinery, and buildings for which the Government advanced, the Government set up as their own property upon the works certain plant, machinery, and buildings which were left, though Government property, upon the company's land at the conclusion of the war. Such mixed ownership was inconvenient. A bargain had been struck which pleased both parties, and for £10,000 the company had a property which was available for manufacturing purposes. The third item was one of £50,500, with which the Directors proposed to redeem the whole of the outstanding Debentures. From the point of view of capital, the company was a relatively small one, and in difficult times and commercial crises it was always well to feel that they had deep water beneath them. From the revenue point of view a small company such as this was better credited in the open market if it was able to say that it had no debentures. That meant they could do better business when they went into the market with their credit in their hands. It was far better at the present moment to give credit than to ask for it. At this moment a firm which was able to give credit in foreign countries in establishing new markets was the firm which was planning well for the future, obtaining goodwill for the future, and they were anxious to lift the company into the top tier of manufacturing companies—companies that can give credit and not have to ask for it. They wished to enjoy the advantage of a company which could say this—No Debentures. The items enumerated roughly came to £96,000, and if they sold their Preference and Ordinary shares at par there would be left available for extension and developments something like £34,000. The money required to pay dividends at 7 per cent. on the 80,000 New Preference shares and 12½ per cent. on the 80,000 New Ordinary shares was £10,000. The repayment of the Debentures would mean a saving in Debenture interest and sinking fund of £6,000 per year, and the repayment of the loan from the Ministry of Munitions would mean a saving of interest amounting approximately to £3,140 per annum, leaving therefore a balance of only £2,450 to be found out of the profits.

SECURING THE SUCCESS OF THE ISSUE.

Mr. MACKINDER, proceeding, said they had been able to sell the whole of the issue on favourable terms. The directors had made it a condition that present shareholders in the company should have a preferential right to take shares at these prices, provided that they gave notice of their requirements. After all expenses had been paid there would be a considerable margin in the way of premium to the advantage of the company, and that premium would be available to be put in the reserve fund. Referring to the profits of the company during the past four years, the chairman said these profits had not been obtained at the expense of those whom the company employed. Both the wage-earners and the staff which was paid salaries had had their position steadily improved during the war, and he had no hesitation in saying that the staff and the men were one of their great assets.

Mr. HUTCHINS, managing director, seconded the resolution, which was unanimously carried.

The meeting then gave their sanction to the necessary alterations in the articles of association.

A special general meeting of shareholders immediately followed, after which came a meeting of Participating Preference shareholders, and both these meetings confirmed the adoption of the resolutions.

The Chairman announced that a further extraordinary general meeting of the company would be held on December 8 to confirm the special resolutions passed. B 712

The National Foremen's ASSOCIATION OF THE ENGINEERING AND ALLIED TRADES.

(Registered under the Trade Union Act.)

An Association specially formed to look after the interests of Foremen on their Supervisory Capacity. A 830

All communications to— H. W. RHID, General Secretary. Head Offices— 81, High Holborn London, W.C.1.

Society of Technical ENGINEERS.

Central Offices: 102, BELGRAVE ROAD, S.W. 1.

A MASS MEETING

of the South Eastern District will be held at

THE CENTRAL (SMALL) HALL, WESTMINSTER (close to Westminster Abbey; entrance in Princes Street),

On TUESDAY, 2nd DECEMBER, 1919, at Seven p.m.

Speaker:

C. H. WORDINGHAM, Esq., C.B.E., M.Inst.C.E., M.I.Mech.E., M.I.E.E., A.Inst.N.A.

Tickets may be obtained from LOCAL SECRETARIES or the Central Offices.

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TENDERS.

COUNTY BOROUGH OF ST. HELENS.

The ST. HELENS CORPORATION ELECTRICITY COMMITTEE offers

For Sale the following Plant:—

One Willans-Dick, Kerr 500 kw. Set, shunt wound 460/500 volts, compound 500/550 volts.
One Willans-Mather & Platt 300 kw. Set, shunt wound 500 volts.
Both suitable for working with a boiler pressure of 160 lbs. per sq.-inch.
Two Wheeler Surface Condensers, 20,000 lbs. steam each.

The plant is in working condition and can be seen by appointment.

Full particulars can be obtained from the undersigned.

Tenders for above should be sent in by 8th December, 1919.

The highest or any Tender not necessarily accepted.

B. T. HAWKINS,
Borough Electrical Engineer.
Electric Power Station,
Carlton Street,
St. Helens. B 683

G. R.

The Admiralty have for Sale

the SALVAGE VESSEL "MELITA," lying at H.M. Dockyard, Devonport.

Particulars are as follows:—

Length, B.P.		165 ft.
Breadth Ex.		31 ft.
Tonnage (approx.) ...		{ Registered 263. Gross 442.
Displacement		850 tons (approx.).
Boilers		2 Cylindrical Working Pressure, 145 lbs. per sq. in.
Engines		Horizontal Triple Expansion I.H.P. 1120 (forced draught) Surface Condensing.

The vessel is fully equipped with suitable plant for undertaking salvage operations.

Tender forms with permission to inspect may be obtained from the DIRECTOR OF CONTRACTS, Branch 8, Room 80, West Block, Admiralty, London, S.W. 1.

Tenders will be received up to Twelve o'clock noon on Monday, 22nd December, 1919. B 586

Sale by Private Tender.

COMPLETE ALTERNATING CURRENT GENERATING PLANT, CONSISTING OF:—

One 525 B.HP and Two 300 HP. Carels three-cylinder Diesel Oil Engines, with Reavell Compressors, direct coupled to—
Two 218 Kw. and One 325 Kw. Dick-Kerr two-phase, 2000 volt, 50 period Alternators, with Direct-coupled Exciters.
Complete Auxiliary Gear, consisting of Reavell four-stage Compressor, driven by direct coupled 2000 volt, two-phase, 100 HP. Induction Motor, Marble Switchboard with Mechanical Remote Control for Three Generator and Two Feeder Panels, with the usual measuring and synchronising gear. Motor-driven, water circulating and fuel Oil Pumps; Heenan and Froude Water Cooling Plant for 7000 gallons per hour, Cooling Water and Fuel Oil Tank, Fuel Oil Storage Tanks of 90 tons capacity, and a quantity of New and Second-hand Spare Parts.
Also One 20 ton Engine Room Crane, 47 ft. span, with Hand Traverse and Electric Hoist; and One 15 ton Ditto, Hand Traverse and Hoist, 37 ft. 6 in. span.

The whole is in good running order and adjusted to run on either tar or crude oil.

The Plant may be inspected by prospective purchasers by appointment.

Offers will be considered for whole or part of above Plant. B 606

THE DAIMLER COMPANY, LTD., Daimler Works, Coventry.

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSALS BOARD. (Plant and Machinery Section.)

FOR SALE BY PUBLIC TENDER.
CHEMICAL AND ENGINEER'S PLANT.
DONKEY COOLING PLANT.

Tenders are Invited for the

following:—

31 Donkey Cooler channel staunchions, 22 ft. 3 in. long.
210 Donkey Cooler Trays, nearly new.
30 Donkey Cooler Trays, not used.
25 Donkey Cooler Trays, partly prepared.
230 End Plates for same.
KESTNER MATERIAL.
Six Large Type Separators with 3 in. pipes and bends.
16 Small Type Separators with pipes and bends.
Two Sets Triple Effect Condensers with brackets.
Three Sets Double Effect Condensers.
Four Sets 9 in. Vapour Collecting Mains with 5 in. branches.
Four Sets 12 in. Ascension Pipes. 4 ft. 9 in. Pipes with 12 in. by 5 in. branches.
24 1½ in. Safety Valves. 24 ft. 5 in. Sluice Valves.
24 5 in. Pipes, 2 ft. 7 in. long.
Ref. G.421. N.K. No. 13,340 to 51.
Tenders close December 15th, 1919.
Above lying at Messrs. Brunner Mond & Co., Ltd., Sandbach Works, Northwich.
Permits to view and Tender forms can be obtained on application to the CONTROLLER, D.B.1.(S), Charing Cross Embankment Building, London, W.C. 2.
NOTE.—For particulars of other Government Property for sale, see "SURPLUS," price 3d. at all Bookstalls; or by quarterly subscription of 2s., post free, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. B 625

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD. (PLANT AND MACHINERY SECTION).

FOR SALE BY PUBLIC TENDER

VALUABLE MACHINE TOOLS, ETC.,
Lying at Clyno Engineering Co., Limited, Pelham Street, Wolverhampton.

Tenders are Invited for the

following:—

Three Lincoln Milling Machines.
One No. 8 Fellows Gear Shaper.
Two Taft Pierce Universal Grinders, 10in. by 30 in.
Four Straight bed S.S. and S.C. Lathes, 9 in. to 13 in. centres.
Two No. 9 Herbert Combination Turret Lathes.
Five 1 in. Herbert Capstan.
One Van Norman Universal Miller.
One Burton Griffiths Plain Miller by Gooley and Eduud.
Two 8 in. by 5 ft. straight bed S.S. and S.C. Lathes.
Two Milwaukie Vertical Millers, size 1½ B.
Three Landis Plain Grinders, 12 in. by 36 in.
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One Archdale Thread Miller, 9 in. centre.
One No. 1 Slot Driller by Richards & Co.
Four Warner & Swasey No. 4 Universal Turret Screw Machines, capacity 1½ in. Bar.
One 3 ft. 9 in. Elevating Radial Drill by Asquith.
One 9½ in. centre by 5 ft. Relieving Lathe by Smith & Coventry.
One Buckton 60 ton Vertical Single Lever Testing Machine.
Two No. 13½ Garvin Plain Milling Machines.
Three "Porter Cable" Lathes, 7 in. centres by 2 ft. 8 in. bed.
Two 3 ft. 9 in. Elevating Asquith Radial Drills.

Permits to view and all further information, can be obtained from the CONTROLLER, D.B.1.e., Charing Cross Embankment Buildings, London, W.C. 2.

Tenders to be lodged by 10 a.m., December 8th.

NOTE:—For particulars of other Government Property for Sale, see *Surplus*, price 3d., at all Bookstalls; or by quarterly subscription of 2s. post free, payable in advance, to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. B 576

DIRECTORS OF THE SHANGHAI WATER WORKS COMPANY invite

Tenders for about 5,000 yards

OF LAP-WELDED STEEL SPIGOT AND SOCKET PIPES, of diameters varying from 40 inches to 36 inches; together with a number Bends, Outlets and other specials. Also a numberof gear d and other valves of like diameters. Specificationsand further particulars may be obtained from the Company's Consulting Engineers, Messrs. JOHN TAYLOR & SONS, 36, Victoria Street, Westminster, S.W. 1. (Signed) WM. WALKER, Secretary. B 736

DUNDEE WATER COMMISIONERS.

CAST IRON PIPES.

The Dundee Water Commissioners are prepared to receive

Tenders for the Supply of

850 Tons or thereby of 15 in. CAST IRON PIPES.

Specification, Schedule, and Form of Tender, may be obtained from the subscriber, and offers, marked "Tenders for Cast Iron Pipes," should be lodged with WM. H. BLYTH MARTIN, Esq., Town Clerk, Dundee, not later than 12 noon, on Tuesday, 2nd December next.

The lowest or any offer may not be accepted.

GEORGE BAXTER,
Engineer and Manager.
93, Commercial Street,
Dundee.
15th November, 1919. B 735

GLASGOW CORPORATION TRAMWAYS.

GRANITE PAVING SETTS.

The Corporation invite

Offers for the Supply of

Granite Paving Setts REQUIRED by the Tramways Department.

Specifications and Forms of Tender may be obtained on application to Mr. JAS. DALRYMPLE, General Manager, 46, Bath Street, Glasgow.

Sealed offers, marked outside "Tramways—Tender for Granite Paving Setts," must be lodged with the Subscriber, on or before Tuesday, 25th inst.

The lowest or any offer may not be accepted.

J. LINDSAY,
Town Clerk.
City Chambers, Glasgow.
12th Nov., 1919. B 703

Tenders are Invited for

CEMENT PLANT MACHINERY, CONSTRUCTIONAL STEEL-WORK, ELECTRIC POWER PLANT, &c.

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THE BRINELL AND SCRATCH TEST OF HARDNESS.

By Dr. W. C. Unwin, F.R.S.

It is well known that the very useful Brinell test of hardness is not quite satisfactory for very hard steel. On account of the smallness of the indentation and the deformation of the ball the errors of the test probably increase as the material tested is harder. Hence the old test of scratching the surface with a loaded diamond point and measuring the width of the furrow has been looked to as possibly more trustworthy than the Brinell test where the latter seems to fail.

Recently, Sir Robert Hadfield and Mr. S. A. Main have published a Note on Brinell and Scratch Tests (Journal of the Institute of Mechanical Engineers, October, 1919), containing determinations of hardness by both methods on steels varying from 104 to 741 Brinell. No such series of tests has previously been accessible, and as they were made with very great care they are of great value. The results of the scratch tests are somewhat discrepant, but as they depend on the measurement of the width of a scratch varying from three to six hundredths of a millimetre, this is not surprising. In any case the scratch test cannot be expected to be as sensitive or accurate as the Brinell.

The most novel point in these tests is that for very hard steel the scratch hardness number is much greater than the Brinell number. For instance:—

Brinell.	Scratch.
670	1,110
696	1,220
741	1,345

But it must be pointed out that this depends on the assumption that the scratch hardness is represented by the expression:

$$H_s = \frac{0.02675}{w^3} \quad . \quad . \quad . \quad . \quad (1)$$

where w is the width of scratch in millimetres. The results have been plotted logarithmically and the index of w determined by drawing a line averaging the plotted points, a quite legitimate proceeding. But where the observed points are discrepant there is difficulty in drawing the line accurately enough to determine the index of w.

Scratch Test.

Brinell.	Error of $\frac{0.02675}{w^3}$.	Error per Cent.	Error of $\frac{0.68}{w^2}$.	Error per Cent.
364	−125	34·3	− 70	19·2
364	− 80	22·0	− 35	9·6
340	− 54	15·9	− 10	2·9
353	− 32	9·1	+ 3	0·9
337	− 16	4·8	+ 19	5·6
351	− 30	8·6	+ 5	1·4
302	+ 77	25·5	+100	33·1
332	+ 80	24·1	+ 88	26·5
382	+ 30	7·7	+ 38	10·0
405	+ 7	1·7	+ 15	3·7
337	+100	29·7	+190	56·4
402	+176	43·8	+125	31·1
477	+101	21·2	+ 50	4·4
690	−112	16·3	− 63	9·1
645	− 23	3·6	− 92	14·5
696	− 74	10·6	−143	20·6
696	− 74	10·6	−143	20·6
645	− 23	3·6	− 92	14·3
696	− 74	10·6	−143	20·6
718	− 43	6·0	−131	18·3
645	+ 55	8·5	− 26	4·0
670	+440	65·8	+145	21·7
696	+524	75·3	+172	24·7
741	+604	81·5	+186	25·1
	24)	540·8	)	398·3
Mean error per cent. ..		22·5		16·6

Now there is some reason for thinking that scratch hardness varies inversely as the square and not as the cube of w. Sir Robert Hadfield's results are fairly well represented by the expression:

$$H_s = \frac{0.622}{w^2} \quad . \quad . \quad . \quad . \quad (2)$$

To test this let H_b be the Brinell number, H_s the scratch number, and let $H_s - H_b$ be called the error or deviation of the formula. Expressed as a percentage of the Brinell number the error per cent. is:

$$\frac{100\,(H_s - H_b)}{H_b}$$

Making the calculation for the 40 results, the mean error is:—

	Per Cent.
Formula (1)	57·7
Formula (2)	52·9

Which seems to show that one equation fits the results as well as the other.

The interest of the scratch test is chiefly its application to the harder steels. For mild steel the Brinell or Ludwig test is easier and more accurate. Also there is some probability that the error of the scratch test is greatest in the most ductile material.

Now taking the 24 results on steels varying from 302 to 741 Brinell, the expression which fits the results best is:

$$H_s = \frac{0.68}{w^2} \quad . \quad . \quad . \quad . \quad (3)$$

It will be seen that equation (3) agrees better with the observations than (1). The mean error is:—

	Per Cent.
Formula (1)	22·5
Formula (3)	16·6

The error is less than when the softer steels are included, and also the excessive difference between the Brinell and scratch hardnesses for very hard steel disappears. Taking all the higher results:—

Brinell.	$\frac{0.02675}{w^3}$.	$\frac{0.68}{w^2}$.
696	622	553
696	622	553
696	622	553
718	675	587
670	1,110	815
696	1,220	868
741	1,345	927
Mean error per cent.	32·1	21·6

It seems a reasonable assumption that scratch hardness is proportional to the work expended on removing unit volume of material. Let H_s, w be as before, l the length of the scratch, k a constant depending on the form of the diamond point, and P the load. Then it is not a far-fetched assumption that the work expended is proportional to $P\,l$, and the volume removed is $k\,l\,w^3$. Hence, the work expended per cubic unit is proportional to:

$$H_s = \frac{B\,P}{w^3} \quad . \quad . \quad . \quad . \quad (4)$$

where B is constant for a given diamond point.

Martens defined scratch hardness as the load required to produce a scratch of a given width. But if w is constant H_s is proportional to P in accord with Martens definition.

If P is constant as in Sir Robert Hadfield's tests H_s varies inversely as w^2 as in equations (2) and (3).

But obviously, if the scratch test is to be taken as giving more than qualitative values, further investigation is required. Tests with two or three values of P are desirable, and perhaps it would be useful to examine the form of the scratch by making a section. It is worth consideration whether the edges of the scratch can be made more definite for microscopic measurement, say by dulling or smoking the surface before making the scratch.

THE WORKS AND PRODUCTS OF MESSRS. BARR AND STROUD, LIMITED.

(*Continued from page 540.*)

In our last article we dealt with a naval and fortress rangefinder in considerable detail and illustrated some forms of mounting. We now propose to refer briefly to some other of the types of rangefinders and mountings manufactured by Messrs. Barr and Stroud, Ltd. As we have already pointed out, the whole series of instruments are in the *essentials* of their optical features identical, and it is unnecessary further to refer in detail to the mode of operation. The instrument we described in our last article was of a type made up to a base length of 12 ft., and we now, in Figs. 55 and 56, on page 670, give illustrations of one of the largest types of rangefinder manufactured by the firm. This instrument is made up to a base length of 35 ft. and is intended mainly for fortress work. For comparison, Fig. 55 shows the smallest size of rangefinder manufactured. It can be seen to the left of the pedestal.

As will be seen from the figures, the great increase in base length of this instrument, as compared with shorter models, has given rise to a change in the construction of the outer tube. This is made in three parts with bolted flanges at the joints. It will also be noted that this instrument is supported in its mounting at four points instead of two only, as with the instrument we illustrated in our last article, or as in the example shown in Fig. 57, on page 670. Two intermediate supporting members carry the bearings in which the instrument lies, and are in turn pivoted at their centres by arms carried out from the pedestal head. It will be clear that this type of suspension gives a flexible support to the instrument and does not constrain it in any way. This flexibility is an important feature. Were four rigid points of suspension provided it would be difficult, or impossible, to ensure that each took a fair share of the load, and the effect of one support shirking its work might be that the instrument would deflect slightly with possible effect on the optical parts. The wire cage arrangement over the instrument, which can be seen in Fig. 56, is introduced for the purpose of preventing the optical parts getting out of alignment owing to deformation of the outer tube. The cage is fitted for the purpose of carrying a canvas sunshade for use in hot sun. As we mentioned when dealing with the works, all rangefinders are tested and calibrated in a heated chamber during manufacture, but the effect of a hot sun shining on one side only of the instrument might result in distortion which calibration in a heated chamber would not allow for.

It is not necessary to refer in any great detail to the construction of the mountings shown in Figs. 55 and 56, as their main features will be clear from the illustrations. This type of mounting is for use in gun turrets in a fortress. When mounted in a gun turret the ends of the instrument project through the side armour. Two observers are required to use the instrument, sometimes three are employed. One observes the range field and the scale through the right and left eyepieces in the manner described in our last article. This observer also controls the instrument in altitude by means of a small hand wheel which operates a worm on a toothed quadrant. This control is placed conveniently to the observer's left hand. It can be seen in both figures, a small circular hand wheel being fitted in Fig. 55 and a toothed hand wheel in Fig. 56. The instrument is controlled in azimuth by a second operator, who is provided with a sighting telescope. He trains the instrument by means of the hand wheel which can be seen in the figures and which rotates the pedestal head through a worm gearing. Before leaving the question of mountings, we should refer to Fig. 57, which shows a type employed inside naval turrets for instruments, up to 9 ft. base. As will be seen, in this case the mounting is very compact, takes up little space, and is designed to be bolted to a bulkhead. This instrument and mounting are designed to require the minimum head room and, as will be seen from the figure, the eyepieces are arranged so that the observer looks directly into them horizontally. The azimuth control of the instrument is operated by a second observer who uses the hand wheel shown. He views the field through a periscope, the vertical tube of which can be seen behind the instrument.

The rangefinders shown in Figs. 55 and 56 are made in base lengths from 28 ft. to 36 ft. The two instruments shown are in general similar, but the model illustrated in Fig. 56 is a later design than that shown in Fig. 55. Naval rangefinders of from 20 ft. to 35 ft. base have larger optical parts and a larger diameter of outer tube than the rangefinders illustrated in Figs. 55 and 56. In the smaller instrument the pentagonal prisms are of the solid type, as illustrated and described in our previous article, but in the larger a form of built-up double reflector has been used consisting of discs of glass suitably mounted together. This arrangement has been adopted since it is practically impossible to obtain blocks of glass free from impurity or defects of sufficient size to make these large reflectors in pentagonal form. The fortress and naval instru-

FORTRESS RANGEFINDERS AND MOUNTINGS.

CONSTRUCTED BY MESSRS. BARR AND STROUD, LIMITED, ENGINEERS, ANNIESLAND, GLASGOW.

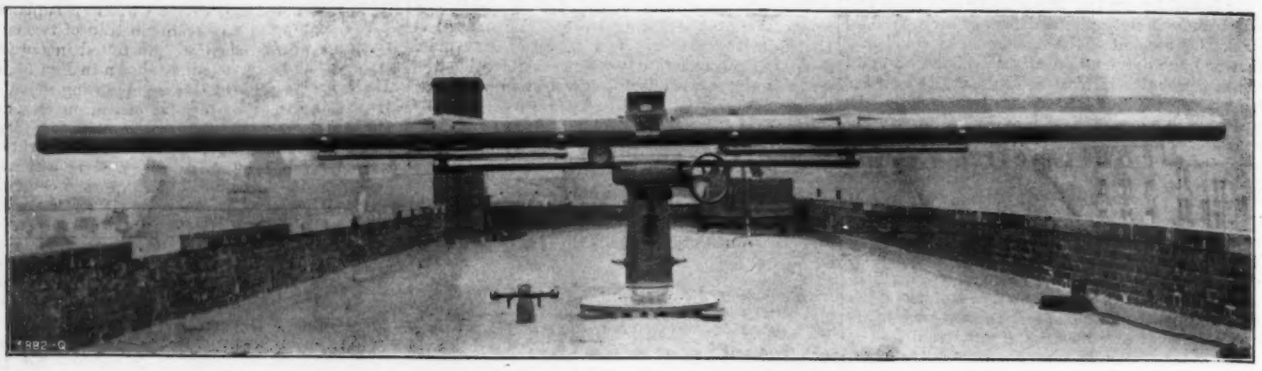


FIG. 55. VIEW SHOWING COMPARISON BETWEEN LARGE AND SMALL RANGEFINDERS.

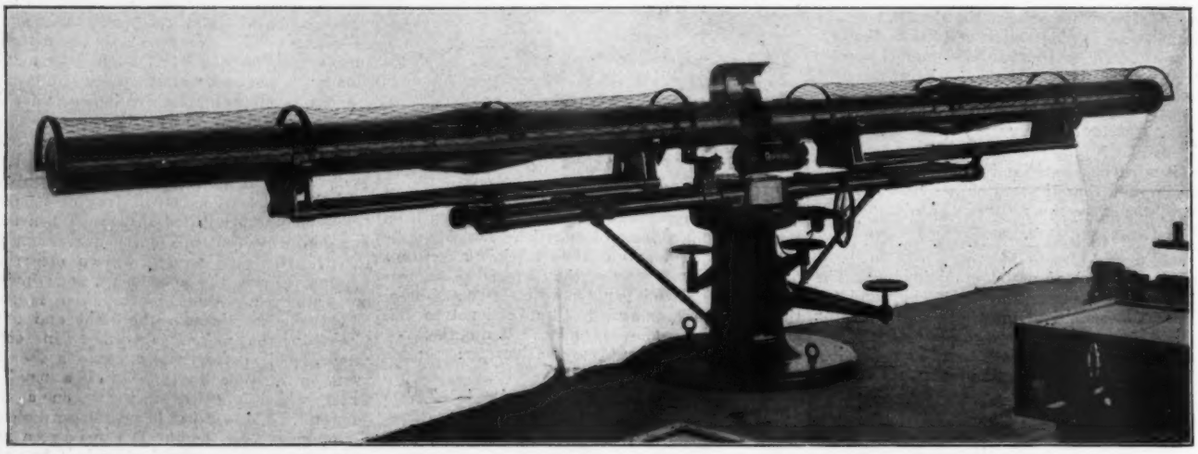


FIG. 56. LARGE FORTRESS RANGEFINDER AND MOUNTING.

ments are identical in the ranges they are intended to deal with and the reason for the larger pentagonals and objectives in the latter instrument is to obtain a better illumination and consequently a clearer image. This matter is of importance when visibility is low; but it does not add to, and may indeed detract from, the accuracy of range measurement.

As we have already said, the optical features of these large rangefinders follow in principle and general arrangement those of the smaller type of instrument already described in detail. They, however, contain an additional optical device which is not contained in the smaller instruments and which we have not yet referred to. This consists in an arrangement for testing the accuracy of the reading of the instrument. It may be remembered that when dealing with the workshops we described how posts were set up at known distances in the country surrounding the works, and that check readings could be taken on these posts from the rangefinder adjusting shop. This process of testing on a known distance can be repeated in some circumstances, *e.g.*, in connection with fortress rangefinders a pole, or other suitable object, can usually be set up at a known distance and used from time to time to check the reading of the instrument. If for any reason it is not reading accurately it may then be adjusted by means of the coincidence adjustment we described in our last article.

In the case of portable instruments and instruments on ships some other method of obtaining a check reading must be obtained. The simplest is to take a reading on a celestial object which, if the

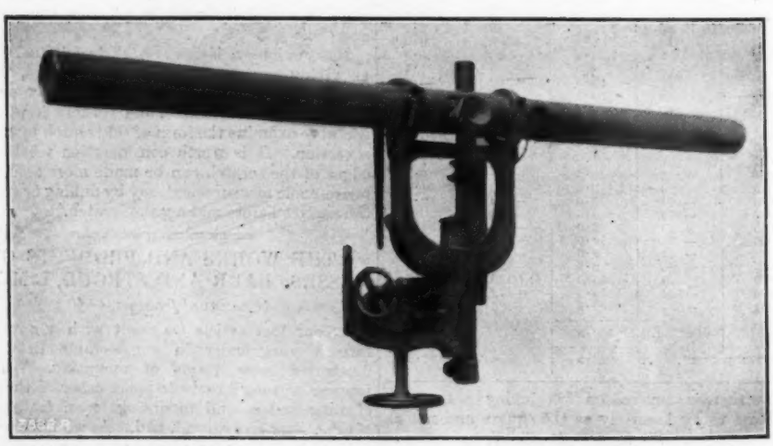


FIG. 57. RANGEFINDER AND MOUNTING FOR NAVAL TURRETS.

Fig. 58.

NAVIGATIONAL RANGEFINDER.

CONSTRUCTED BY MESSRS. BARR AND STROUD, LIMITED, ENGINEERS, ANNIESLAND, GLASGOW

Fig. 59.

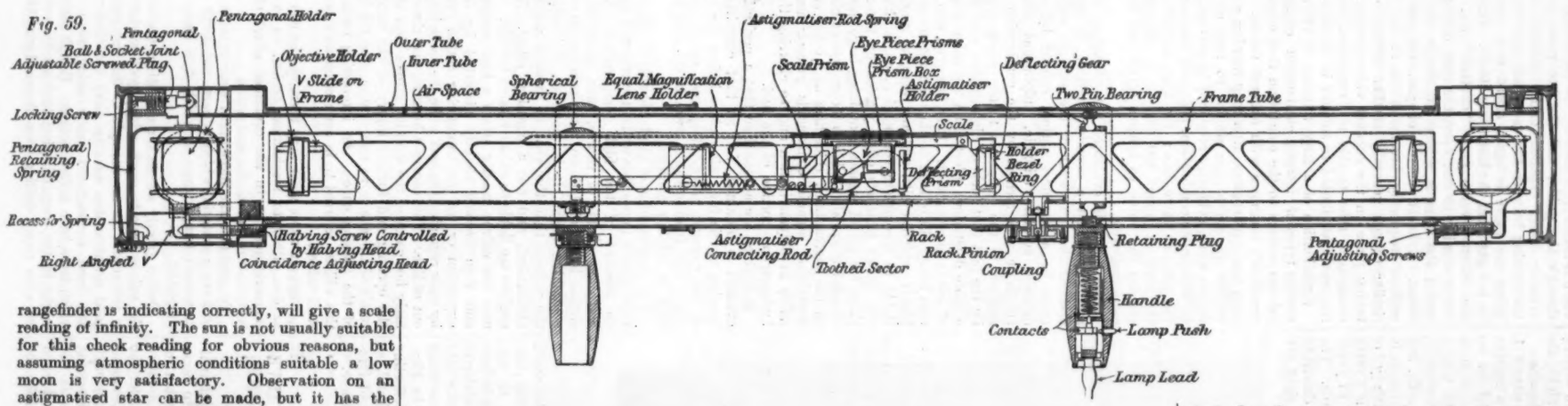


FIG. 60 66-CMR. BASE RANGEFINDER IN USE.

rangefinder is indicating correctly, will give a scale reading of infinity. The sun is not usually suitable for this check reading for obvious reasons, but assuming atmospheric conditions suitable a low moon is very satisfactory. Observation on an astigmatised star can be made, but it has the disadvantage that the astigmatiser has to be used, which in the case of slight maladjustment of the astigmatiser parts might introduce an error of its own. This adjustment—on a celestial object—has the disadvantage that it cannot be carried out in cloudy weather, and some method of adjusting which is always available is very desirable. It is possible to adjust a rangefinder on *two* objects at unknown range by measuring the distance from one to the other by means of the rangefinder and then placing the instrument between them and measuring the two short ranges so given. If the rangefinder is not reading correctly the sum of the short ranges will not equal the long range. The difference between the totals gives a measure of the inaccuracy of the instrument, and can by calculation be used to adjust it, but it is not necessary that we should go into the arithmetic of the matter here.

Adjustment of a rangefinder may also be carried out by means of an artificial infinity. This may be produced by having two marks on a board, or frame, at a distance from one another equal to the base length of the rangefinder. If the board is then set up some distance from the rangefinder, preferably more than 100 yards away, and the board is viewed through the instrument, the coincidence of the images of the two marks in the field of view of the rangefinder should agree with a scale reading of infinity. If the board is placed at some considerable distance from the rangefinder the effect of any slight want of parallelism between the board and instrument will be negligible. Another method of adjustment is to optically reduce the base of the rangefinder to zero. This may be done by arranging two similarly disposed reflecting prisms, one in front of each of the end reflectors of the rangefinder, the one covering the lower half of one aperture and the second the upper half of the other aperture. In this way a target may be viewed with the axis of the instrument in line with it, *i.e.*, with the equivalent of a zero base, at all events if the two reflectors set out angles of 90 deg. If the angles set out are not quite 90 deg., the equivalent base may be a small positive amount, but, if pentagonal prisms are used, on turning each prism through 90 deg. about a vertical axis, and looking at a target 180 deg. from the first (or swinging the rangefinder through 180 deg. about a vertical axis so as to view the original target) the base will have a negative value of the same small amount. This is to say, the reading of the apparent range of a target at any distance will be in the one position a small amount below the nfinity mark and in the second position an equal amount above the infinity mark. The mear of the two observations gives the adjustment for infinity. Instead of using any target that may be available, it is customary to supply a self-contained target in the shape of a collimator at each end of the instrument. This method has been used by Zeiss and others, but has some serious disadvantages.

The Barr and Stroud self-contained adjuster illustrated diagrammatically in Fig. 58 on page 670, consists of two lenses (L^1 and L^2) and two small pentagonal prisms (P^1 and P^2) placed at the ends of the rangefinder. The focal lengths of the two lenses are equal, and a few centimetres shorter than the base length of the instrument. At the centre of each of the lenses there is a fine mark. These marks are illuminated by light reflected on to them through the small prisms p^1 and p^2 and the lenses are placed so that the mark on one lens is in the principal focal plane of the other. The parallel beams of light emerging from the lenses are reflected by the pentagonal prisms P^1 and P^2 into the end reflectors of the rangefinder and the images of the fine marks appear in the field view as bright vertical lines, the alignment of which can be readily observed. When it is desired to adjust the rangefinder, shutters are inserted at the ends of the instrument, which cut off all light except that passing through windows placed opposite the small prisms p^1 and p^2. This light may be daylight, or proceed from small electric lamps.

If the marks are so placed that the axes of the emergency beams are truly parallel to each other, the beams will virtually come from objects, of the form of the marks, placed at an infinite distance in front of the rangefinder. The beams will be truly parallel if the centres of the marks coincide with the optical centres of the lenses, and the prisms P^1 and P^2 set out angles of 90 deg., or complementary angles. In practice this condition is difficult, if not impossible, to attain, and to enable the makers, once for all, to adjust the device so as to be equivalent to a true infinity, an achromatic refracting prism of very small angle is inserted between the lenses L^1 and L^2, and this prism is rotated about its centre to make the required adjustment. When so adjusted the prism is fixed in position and need not again be disturbed. As this adjuster is added to the instrument for checking purposes it is of interest to consider the possibility of the adjuster itself going out of adjustment.

It will be clear, however, from Fig. 58 that this is not a likely contingency. The adjuster is a very simple device and has *no moving parts*. In addition to this, however, the optical properties of the arrangement are such that any relative movement of the lenses in the adjuster will not affect the parallelism of the emergency beams. If it be supposed that lens L^1 is moved to the position shown dotted in Fig. 58, then the mark attached to it will be moved by the same amount as the optical centre is moved, and therefore the beams emerging from the two lenses will take up the positions indicated by the broken lines in the figures and the *parallelism of the beams* emerging from the pentagonal reflectors will not be disturbed. It may be noted that although the adjuster pentagonals are placed immediately in front of the rangefinder pentagonals, they do not appreciably affect the beams of light entering the rangefinder under ordinary working conditions, owing to the fact that they are very thin and are so placed that they are quite beyond the focus of the rangefinder eyepiece.

Turning now to the remaining instruments which we illustrate this week we may first refer to Fig. 59, on page 671, which gives a vertical longitudinal cross-section of a navigational rangefinder. The purpose of this instrument is given by its name. It has a base length of 0 m. 80 or 1 m., a magnification of about 15 diameters, and an angle of range field of about 3 degrees horizontally and 1 deg. 15 minutes vertically. The lowest scale indication is 200 yards. As will be clear from the figure, the instrument can be held in the hands. An examination of the figure will show that the various optical parts are similar to those in the rangefinders we have already described. The instrument is an example of one of those in which the scale is attached directly to the deflecting prism, and is moved to and fro past the eyepiece as the deflecting prism is adjusted to give coincidence of the half-images. A difference in this instrument from those previously described is that the frame tube, carrying the optical parts, is of square section and is perforated throughout its length and on all sides. This perforation is for the purpose of cutting down weight and to assist in the even distribution of heat. It will be seen that the instrument is provided with an electric lamp, so that the scale may be read at night, the lamp lead being taken through one of the handles.

Our remaining illustrations, Figs. 60, on page 671, and Figs. 61 and 62, subjoined, show a smaller instrument of 66 cm. (26 in.) base, used for infantry service in the field. The magnification is 12 to 14 diameters, and the angular range field is 3 deg. horizontally and 2 deg. 10 minutes vertically. The lowest scale reading is usually 250 yards, and the highest 10,000 yards, or equivalent distances in other units. The approximate uncertainty of observation, under favourable conditions, is 2 yards at 500 yards; 7·5 yards at 1,000 yards; 67 yards at 3,000 yards; and 270 yards at 6,000 yards. The double eyepiece arrangement, already described for larger instruments, is employed, the right eye observing the range field and the left the scale. The eyepieces are placed at an angle of 60 deg., this makes the instrument more comfortable to use. The instrument weighs about 7 lb., and can be held in the hands, but naturally is somewhat easier to use if rested on a stand. A small portable field mounting is shown in Fig. 60, while a taller mounting at which the observer stands, is shown in Figs. 61 and 62. It should be said that the deflecting head is placed conveniently to the right-hand, so that it may be operated by the thumb and forefinger without releasing hold of the main handle.

(To be continued.)

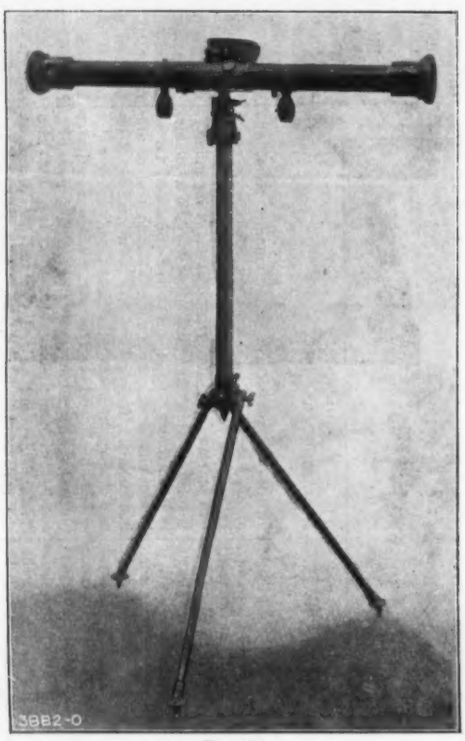


Fig. 61.

Fig. 62.

Figs. 61 and 62. 66-Cmr. Base Rangefinder on Portable Mounting.

MATERIALS FOR THE EXHAUST VALVES OF INTERNAL-COMBUSTION ENGINES.

By J. E. Hurst and Harold Moore.

There is probably no part of an internal-combustion engine so liable to wear and to cause trouble as the exhaust valve. Modification of design of exhaust valve may to some extent improve matters, but the problem is essentially one for the metallurgist. In the first place let us examine the conditions to which the valve is to be subjected. During the period when the valve is seated, assuming it to be correctly functioning, the valve is not subjected to any severe mechanical or thermal stresses. Towards the end of the firing stroke the valve is raised from its seat, the valve stem moving through the guide, and the hot gases from the cylinder being expelled under pressure through the opening between the valve face and valve seat. When the valve is again closed it is surrounded by hot gas from the last firing stroke. On closing, the exhaust valve may "chatter," *i.e.*, bounce before coming to rest upon the seat, during which period the stem is subject to shocks and tensile stress. Exhaust valves of gas, oil and petrol engines frequently become worn at the face, a similar though generally smaller amount of wear taking place on the exhaust valve seating. It is common to refer to this as "corrosion," and it is frequently attributed to sulphur in the fuel.

Examination of a large number of valves from various types of internal-combustion engines has led the writers to the conclusion that corrosion is practically unknown with exhaust valves. Valves from heavy oil engines, after long running, generally exhibit an appearance similar to that of beaten copper work, evidently produced by carbon, formed by incomplete combustion, becoming trapped under the exhaust valve face; the high temperature of the exhaust (about 400 deg. C. in exhaust pipe) causing the valve to become softer and therefore more malleable.

This effect is evidently not corrosion, being a mechanical, not a chemical action. It has been claimed that the wear of the exhaust valve face must be a chemical action, caused by sulphur dioxide, sulphur trioxide, sulphurous acid and sulphuric acid formed by the combustion of the sulphur in the fuel, this theory being supported by the fact that fuels of high sulphur content have a more deleterious effect upon the valve than fuels of low sulphur content. It is, however, also correct that heavy oils of high sulphur content are generally highly asphaltic oils, and are therefore much more liable to incomplete combustion, as is shown by the smoky exhausts often yielded by these fuels. Fuels for petrol engines containing large quantities of sulphur are also liable to incomplete combustion, as the mercaptans, thioethers and other sulphur-containing organic compounds present are more liable to polymerisation and to charring than the hydrocarbon portion of the fuel.

If engines are adjusted so that a perfectly clear exhaust is obtained, *i.e.*, so that complete combustion of the fuel takes place before the opening of the exhaust valve, little wear on the exhaust valve face is observable, even if the fuel be very high in sulphur content.

The condensation of sulphuric acid on the exhaust valve face is impossible whilst the engine is running, on account of the high temperature. A little corrosion might, of course, take place when the engine has cooled down after running on sulphur containing fuels. It is, however, the opinion of the writers that the wear of exhaust valves is a mechanical, and not a chemical effect. Aircraft engines are liable to exhaust valve trouble. In this case the valves usually attain a high temperature and then become slightly distorted by thermal expansion or by the hammering action produced by their regaining the seat while the valve is slightly out of line. This causes a leakage, and the exceedingly hot gases of the working stroke blow through the opening and further injury of the valve is a result of the excessive temperature and the friction of the passing gases. An interesting example of this will be referred to in connection with tungsten steel valves.

Exhaust valve wear may therefore be considered as due either to mechanical action, to excessive temperatures, or to the combined effect of both temperature and mechanical action.

To minimise the mechanical wear it is necessary to have a material which is hard and tough at the maximum temperature to which it is likely to be subjected.

Design greatly affects the conditions under which the valves have to work, whilst good workmanship is essential. As an example of the importance of good workmanship we may point out that trouble has been encountered when using aero valves which have been drilled hollow. Rough machining marks in the form of spiral tool marks, evidently left after rough drilling were shown during the war

to have been responsible for a number of valve failures. A finishing cut should always be taken to remove all the rough machining marks.

The increase of stress produced by eccentricity of the bore, unless extremely bad, is not nearly so important as the internal finish of the bore.

We will mention the various materials available, together with their properties, in turn.

Cast-Iron.—Cast-iron, for obvious reasons, is not a satisfactory material for general use for valve stems, but we give the following analysis from the cast-iron valve stem of a large gas engine :—

	Per Cent.
Combined carbon	0·50
Graphite	2·80
Total carbon	3·30
Silicon	1·68
Manganese	1·00
Sulphur	0·093
Phosphorus	1·24

Cast-iron is too brittle to be used with a satisfactory degree of safety for valve spindles. It is possible to attach a loose cast-iron face to a steel valve ; also it is possible to attach a cast-iron face to a steel valve by welding. These types of valves are sometimes used on engines running at a comparatively slow speed. The use of a cast-iron face screwed on to a steel valve is objectionable, as the poor conduction of heat between face and valve results in the valve face attaining unnecessarily high temperatures.

The use of welded cast-iron exhaust valve faces is far preferable. In order to fix the cast-iron securely a groove is cut into the steel valve head in the position of the face, and cast-iron welded in from a thin rod by means of an oxy-acetylene flame. The groove is so shaped that the cast-iron is dovetailed into the steel when the valve is completed. This procedure has an economical point in its favour, namely that old steel valves badly worn at the face can be filled with cast-iron and used again. The cast-iron wears moderately well, and is preferable to mild steel for slow-speed engine work.

Mild Steel Valves.—Mild steel serves for slow-speed engine work, but the rate of wear is high, for which reason it has almost entirely given place to alloy steel for this purpose.

There is no advantage in using carbon steel, as any hardening operation would make the material too brittle.

Case-Hardened Steel.—Case-hardening produces a very satisfactory hard steel face with a backing of tough mild steel. It, however, becomes annealed as soon as used in an engine unless the valve is water-cooled. For water-cooled valves mild steel, or better, 3 per cent. nickel steel case-hardened, is a most satisfactory material.

Three per Cent. Nickel Steel.—Three per cent. nickel steel has come into common use and been found satisfactory on slow-speed engines.

The Air Board specification K 10 for this material for aero-engines is as follows :—

	Per Cent.
Combined carbon	between 0·3 and 0·4
Silicon	not more than 0·3
Manganese	between 0·3 and 0·6
Sulphur	not more than 0·04
Phosphorus	not more than 0·04
Nickel	between 2·75 and 3·75

The heat treatment recommended for the above material is :—

Oil hardened from	850 deg. C.
Tempered at	600 deg. C.
Brinell limits	205 to 255.
Izod impact not less than 30 ft.-lb.	

The impact figure is important, as there is no doubt that a number of the valves have failed through impact brittleness (Krupp-Krankheit) due to incorrect tempering treatment.

Nickel Steel of High Nickel Content.—An alloy steel of approximately 30 per cent. nickel content has been tried in internal-combustion engines, but does not appear to have been as satisfactory as some of the other expensive alloy steels.

Difficulty is encountered in obtaining regular quality of supplies of this material.

Nickel-Chrome Steel.—These steels have been used for slow-speed engine exhaust valves, and were also largely used for inlet valves on aero engines. Air Board specification K 9 gives the ollowing composition :—

	Per Cent.
Combined carbon	between 0·25 and 0·32
Silicon	not more than 0·3
Manganese	between 0·45 and 0·60
Sulphur	not more than 0·03
Phosphorus	not more than 0·03
Nickel	between 2·8 and 3·5
Chromium	between 1·2 and 1·5

The heat treatment specified is that the forgings shall be heated to a temperature of 820 deg. C. and hardened in oil or air. They are then tempered by heating to 600 deg. C. and quenching in water.

The forgings and stampings are required to be within the Brinell range of 217 to 269, and to give a minimum Izod impact figure of 40 ft.-lb.

This value is of considerable importance for the same reason mentioned under 3 per cent. nickel steel.

The results of a modulus determination by transverse bending for such a steel are given below :—

$$E = 36 \cdot 1 \times 10^6$$

It is of interest to compare this figure with that of the high chrome steel given below.

Chromium Steels for Valves.—These high chromium non-corrodible steels have been largely used in place of tungsten steels for aero-engine valves. They possess the advantage of a lower specific gravity than tungsten steel, and on this account the inertia forces in similar valves are considerably lessened. This is quite an important point in aero-engine valves.

This steel is included in the Air Board standard specification for valve steels S 19. The chemical composition limits as specified are :—

	Per Cent.
Carbon	between 0·2 and 0·4
Chromium	between 11·5 and 14·0
Silicon and manganese	not more than 0·5
Sulphur and phosphorus	not more than 0·06

The steel is required to be heat-treated by a suitable hardening and tempering treatment. The physical test figures specified for the heat-treated material are :—

Ultimate tensile strength	40 tons per sq. in. minimum.
Yield-point	30 tons per sq. in. minimum.
Elongation	18 per cent.
Reduction of area	50 per cent.

A complete series of tests on a sample of this material, including the elastic modulus, which was determined by transverse bending, are given below :—

Chemical Composition.	Per Cent.
Combined carbon	0·33
Silicon	0·33
Manganese	0·35
Chromium	11·50
Physical Tests.	
Ultimate strength	45 tons per sq. in.
Yield-point	32·2 tons per sq. in.
Elongation	17·2 per cent.
Reduction of area	57·4 per cent.
Brinell number	223.
E =	$43 \cdot 6 \times 10^6$.

The modulus of elasticity of chrome steel is apparently higher than that of other steels.

The heat treatment usually given to this steel for aero-engine valves is as follows :—

Air harden	from 900 deg. C.
Temper	from 700 deg. C.
Average Brinell figure	230.

Mercedes Engine Valve.—It is interesting to note the chemical composition of high chromium steel exhaust and inlet valves taken from a Mercedes engine. The analysis as published by the Air Board is as follows :—

	Exhaust. Per Cent.	Inlet. Per Cent.
Combined carbon	1·75	1·82
Silicon	0·58	0·52
Manganese	0·10	0·10
Sulphur	0·048	0·048
Phosphorus	0·013	0·010
Nickel	—	—
Chromium	10·85	10·47

The material shows a considerably higher carbon content and a somewhat lower chromium content than the English material, and indicates the difficulties the Germans were experiencing in making this steel.

Tungsten Steel Valves.—This material is specified for aero-engine exhaust valves in Air Board specification K 8.

The chemical composition specified is as follows :—

	Per Cent.
Combined carbon	between 0·55 and 0·70
Silicon	not more than 0·25
Manganese	not more than 0·25
Sulphur	not more than 0·060*
Phosphorus	not more than 0·025
Tungsten	between 15·0 and 18·0
Chromium	between 3·0 and 4·0
Vanadium	not more than 1·0

The valves are required to be heat-treated to within the Brinell limits of 223 to 269.

The heat treatment specified for this material is as follows : Heat to a uniform temperature of 950 deg. C. and cool in still air, followed by a second uniform heating to a temperature of 800 deg. C., after which the steel is allowed to cool in still air.

A large quantity of the material supplied during the war had a lower carbon content than the above specification, and some typical analyses of this material are given below :—

	No. 1. Per Cent.	No. 2. Per Cent.
Combined carbon	0·08	0·09
Silicon	0·21	0·24
Manganese	traces	traces
Sulphur	0·010	0·012
Phosphorus	0·007	0·009
Tungsten	16·40	16·40
Molybdenum	0·73	0·70
Vanadium	0·97	1·01
Chromium	3·08	3·10

The mechanical tests of this material, after suitable heat treatment, were found to be as follows :—

	No. 1.	No. 2.
Yield-point	28·50 tons	23·75 tons
Ultimate strength	49·60 tons	51·00 tons
Elongation	15 per cent.	17 per cent.
Reduction of area	26 per cent.	32 per cent.
Brinell number	223	217
Stanton (repeated impact)	230 blows	160 blows (2 in. fall)

Temperature Attained by Valves in Aero Engines.—In dealing with aero-engine valves of tungsten steel one of the authors has met with striking evidence of the possible temperature that may be attained under defective conditions in aero-engine exhaust valves. In a particular valve containing from 16 per cent. to 18 per cent. tungsten, owing to bad and defective fitting the valve did not register perfectly on the valve seat, and allowed the hot gases to rush past on one side of the head only. On examining this head it was found to have been burned badly and the form of the seating destroyed. A micro-examination revealed the fact that the material at this point was in the fully hardened condition. This is conclusive proof that the temperature at this point must have been at least 1,250 deg. C.

Cobalt Chrome Steel :—

Yield-point	44·0 tons
Ultimate strength	58·0 tons
Elongation	4·5 per cent.
Reduction of area	5·0 per cent.
Izod impact	1·5 to 1·25 ft.-lb.
Stanton	283 blows
Brinell number	293
Modulus E	$39 \cdot 6 \times 10^6$

This is the cobalt chrome high-speed steel. It has been claimed to be satisfactory for aero-engine valves. The above figures which are taken on the unhardened sample, show the steel to be very brittle, and this steel is not to be recommended on this account.

Further investigation of these steels is needed, and the writers hazard the opinion that a reduction of the carbon content would make this material eminently suitable for valves.

An interesting material for Diesel engine valves has been patented recently (English patent No. 127,256, May, 1919), the approximate composition being :—

	Per Cent.
Nickel	67
Copper	28 to 32
Iron	1 to 5

A hardened steel end-piece is inserted on the camshaft end of the valves. It is claimed by the inventor that this material possesses a coefficient of expansion equal to that of cast-iron, that it resists corrosion at high temperatures, and retains 80 per cent. of its elastic limit and tensile strength at high temperatures.

Calorising Process.—This method of treating

* 0·10 per cent. during the war.

ferrous metals or alloys has recently come to the fore as a means of producing a non-corrodible and hard surface which does not soften or undergo change at the temperatures to which exhaust valves are ordinarily subjected. This process consists in coating certain parts of the valves with metallic aluminium. The treatment is very similar to Sherardising, in which ferrous articles are heated in zinc dust and thereby covered with a coating of zinc.

The calorising process was originally introduced by the Thomson-Houston Company in the United States. It consists of heating the valves in a mixture of alumina and aluminium powder at a high temperature. The aluminium enters into solution in the iron, with the result that an extremely hard, non-corrodible outer layer of ferro-aluminium is produced. This product has a distinct advantage over case-hardened materials in that it does not anneal at high temperatures. The details of manipulation, the temperature, and other conditions require most careful regulation in order to obtain a satisfactory product.

HELL GATE BRIDGE, NEW YORK.

By Frank W. Skinner, M.Am.Soc.C.E.

(*Concluded from page* 606.)

Approaches to Main Span.

The great height of the main span and the necessity for easy grades to facilitate traffic operations, together with the necessity for avoiding grade crossings in a large urban and suburban area where many street intersections exist, with a large amount of present travel and greatly increased travel likely in the future, required very long elevated approaches, the extent of which was still further increased by the maintenance of a high grade for crossing over the Bronx Kill and Little Hell Gate channels (see Fig. 2, on page 169 *ante*), which were accomplished by truss spans. This involved a total length of 13,553 linear ft. of four-track steel construction (Figs. 68 to 71, page 675) in addition to 3,228 linear ft. of embankment between reinforced concrete retaining walls, with arches over the street.

The principal quantities involved in the steel viaduct having a total length of 10,818 linear ft., were 42,235 tons of structural steel, and 200,300 yards of concrete. The viaduct was built at a total cost of 4,452,315 dols., or an average cost of 411·50 dols. per lineal foot for superstructure and substructure, including the cost of tracks. The height of the viaduct varied from about 30 ft. to 120 ft.; the cost per linear foot varied from 230 dols. to 500 dols. per linear foot, and the length of spans, all of which were plate girders, varied from about 50 ft. to 112 ft.

The bridges have in all eight spans, with a combined length of 1,643½ ft., cost 1,790,000 dols., and contain 14,725 tons of steel and 54,000 yards of masonry, increasing the total quantities of the approaches to a cost of 6,242,315 dols., a total length of 11,937½ ft., a tonnage of 56,960 tons of steel, and masonry amounting to 254,300 cub. yards, nearly all of it concrete.

We subjoin statements of the maximum bending moments and maximum shear in the girders illustrated:—

Maximum Bending Moment in 1,000 *Ft.-Lb. per Girder.*

Dead load	2,507
Live load	3,768
Impact	4,521
Total D x L x I...	10,796
Percentage of Impact	120
Sect. modulus required for bottom flange in cub. in. net.	6,478
Sect. modulus used for bottom flange in cub. in. net	6,510

Maximum Shear in 1,000 *Lb. per Girder.*

Dead load	116
Live load	200
Impact	254
Total	570
Percentage of impact	127
Web sect. required in sq. in. net ...	38.0
Web sect. used in sq. in. net... ...	40.5

Plate Girder Viaducts.

Beginning at the north end the viaduct section from 138th-street to 132nd-street (Fig. 2, page 169 *ante*), a distance of 1,736 ft., has plate girder spans averaging 64 ft. long, except over the streets, where they are from 72 ft. to 112 ft. The square concrete piers are supported on pairs of cylindrical reinforced concrete caissons, from 10 ft. to 15 ft. in diameter, sunk through from 6 ft. to 12 ft. of gravel, sand and ashes, and 12 ft. to 25 ft. of mud and silt to a stratum of hard sand and gravel and, in some cases, through a heavy boulder embankment carrying existing tracks of the New York and New Haven Railroad.

The caissons were sunk partly by open dredging with clamshell buckets operated by locomotive cranes that usually carried them down by undermining, and by loading with ballast until they reached nearly to the hard stratum, where in many cases pneumatic pressure was applied for completing the work to the final maximum depth of 55 ft. below the surface. The superstructure of this section of the viaduct contained 7,080 tons of steel and the substructure contained 14,800 yards of concrete masonry, the total cost of construction averaging about 365 dols. per linear foot.

The next section southward is the Bronx Viaduct (Figs. 72 to 76, page 676), extending from 132nd-street 1,071 ft. to the Bronx Kill Bridge. It has deckplate-girders of 72 ft. to 130 ft. span, supported on arched concrete piers of an average height of 60 ft. The average length of span is 89 ft., the total quantity of concrete in the piers is 17,500 yards, the total weight of steel in the superstructure is 4,375 tons, and the approximate cost per linear foot of the viaduct was 445 dols.

As in the northern part of the approach the viaduct piers are supported on cylindrical reinforced concrete caisson foundations that are here from 15 ft. to 18 ft. in diameter, and that were also sunk by open dredging and air pressure through soft silt and mud to a hard stratum of sand and gravel, or rock, at a depth of 45 ft. to 60 ft. below the surface.

The Randall's Island Viaduct adjacent to the Bronx Viaduct is 1,935 ft. long, averaging 85 ft. high, with spans of an average length of 82 ft., and contains 11,610 tons of steel and 29,800 yards of concrete, and was built at an average cost of 370 dols. per linear foot. The arch piers, of an average height of 80 ft., have shallow, narrow concrete footings.

Ward's Island Viaduct, adjacent to Randall's Viaduct, is 2,650 ft. long, with plate girder spans of an average length of 88½ ft., and contains 11,190 tons of steel and 60,300 yards of concrete. It cost 445 dols. per linear foot, and the arch piers are seated on shallow, narrow footings.

The Long Island Viaduct adjacent to the east end of the Hell Gate arch span, is 2,868 ft long, with plate girders of an average length of 85½ ft. It contains 11,980 tons of steel and 77,900 yards of concrete, and cost 500 dols. per linear foot. The arch piers, about 90 ft. high, are generally supported on shallow and wide footings, made in open excavation.

The substructure work was built by the T. A. Gillespie Company, the Arthur McMullen–Patrick Ryan Construction Corporation, and the Snare and Triest Company. The superstructure for the Long Island Viaduct and the Ward's Island Viaduct were fabricated and erected by the American Bridge Company, in connection with the Hell Gate Bridge, and the remainder of the steel superstructures in the approaches were fabricated and erected by the McClintic–Marshall Construction Company, Paul L. Wolfel (chief engineer) and E. A. Gibbs (manager of erection).

Design of Viaducts.

Comparative designs were made by Mr. Lindenthal for the construction of the viaducts in each of three characteristic types of steel tower, rocker bents and arch pier construction. The ordinary steel tower type, with alternating plate girder spans of about 40 ft. and 80 ft., would, for the assumed height of 100 ft., have given an initial economy of about 20 per cent. for tangent work and 15 per cent. for 3 deg. curves, according to computations made when steel could be purchased for normal prices prevailing before the war. With the present high prices of steel probably no economy would have been effected. The cheapness and rapidity of erection of this type were not considered sufficiently important to offset the greater rigidity, durability and better appearance of the type eventually selected.

An alternate design made by Mr. Lindenthal in 1906 provided for plate girder spans of 70 ft. to 80 ft., resting on intermediate steel rocker bents and on solid masonry piers at every tenth span, which were intended to provide resistance for longitudinal forces from braking and traction and to secure rigidity and architectural effects. It was estimated that the economy of this type over the selected type would have been about 10 per cent. on a tangent line and 5 per cent. on a 3 deg. curve.

The design finally adopted by Mr. Lindenthal (Figs. 68 to 71, page 675), had nearly uniform spans, averaging about 82 ft. to 89 ft., supported on arch concrete piers consisting of a main transverse wall, about 6 ft. thick below the coping and reinforced on each side by a pair of buttresses, increasing the stability and adding to the architectural beauty. The 1 : 2 : 4 concrete is reinforced with vertical and horizontal steel bars to prevent shrinkage and temperature cracks, and a grillage of I-beams perpendicular to the axis of the viaduct is imbedded in the concrete just below the bearings for the girder pedestals.

The eight lines of duplicate plate girders are of standard railroad design, and have ½-in. web plates, 9 ft. deep, made in four sections spliced with pairs of 20½-in. by ⅜-in. cover plates having six vertical rows of rivets. The bottom flanges are made with pairs of 8-in. by 8-in. by 1-in. angles and five 17-in. by 1-in. cover plates in the maximum section. The top flanges are made with one pair of 8-in. by 8-in. by 1-in. angles and one pair of 5-in. by 3-in. by ½-in. angles, one 9½-in. by ½-in. and four 18-in. by ½-in. cover plates in the maximum sections. The webs are stiffened by pairs of vertical 6-in. by 3½-in. by ⅜-in. angles crimped over the vertical legs of the flange angles. The ends of girders in adjacent spans abut on cast steel shoes supported by cast steel pedestals with cement mortar bearings that are anchor-bolted to the tops of the piers. The two girders under each track are rigidly braced together by transverse struts and X-bracing in horizontal and vertical planes, each brace consisting of a single angle riveted to connection plates attached to the inner surfaces of the girder flanges.

For the Ward's Island and Long Island Viaducts the girders were distributed by locomotive cranes on the surface of the ground between the piers, and were erected by the mule travellers with 65-ton booms that had previously been used for the erection and dismantling of the backstay trusses. These travellers were somewhat modified for viaduct service by having the vertical columns over the rear trucks removed and the traveller platform seated directly on the trucks.

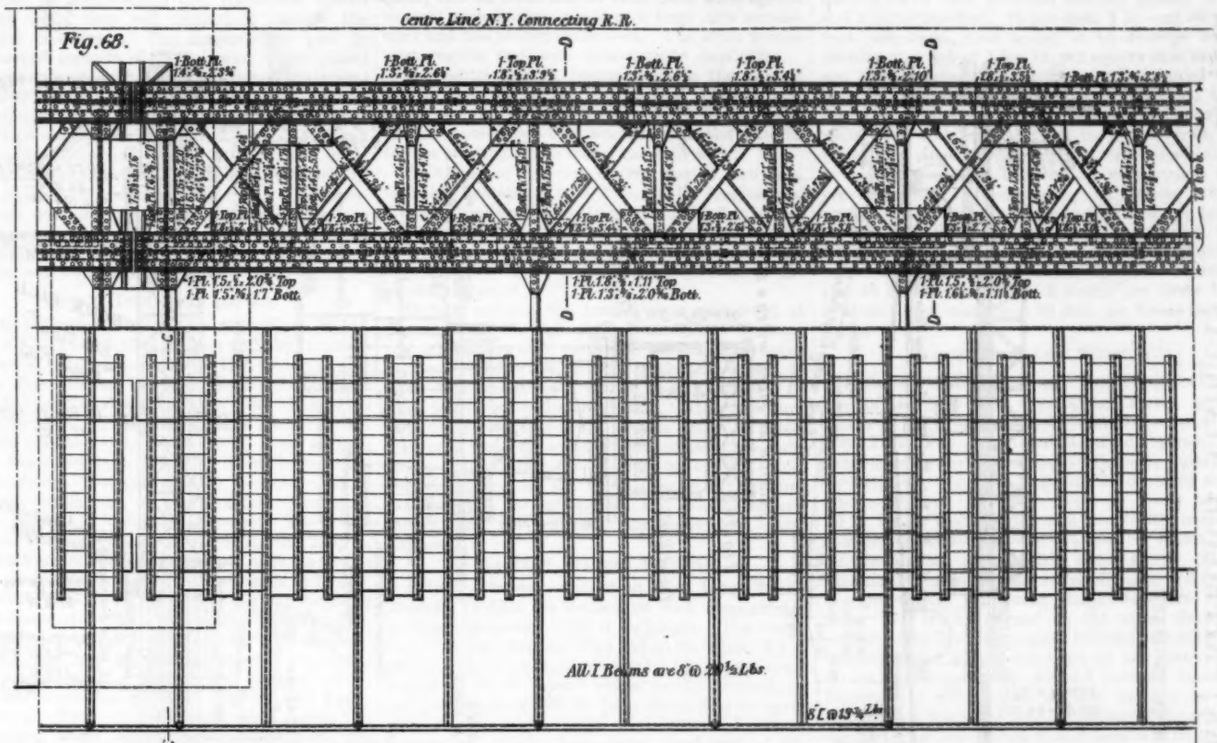
The Bronx and Randall's Island viaducts, which were uniform in design with the Ward's Island and Long Island viaducts, were fabricated by the McClintic–Marshall Construction Company, who erected them with one 50-ton steel derrick car and one 50-ton locomotive crane running on the completed portions of the structure. Most of the girders were riveted up in pairs at the shop and shipped in complete spans weighing about 70 tons each, which were delivered to the derrick car over temporary tracks laid on the viaducts.

Bronx Kill Bridge.

The Bronx Kill Bridge (Figs. 72 to 76, page 676), between Randall's Island and the mainland, nearly 2,000 ft. west of the Little Hell Gate Bridge, crosses the Bronx Kill at an angle of about 72 deg. and a height of 75 ft. above mean high water. The bridge has two 175-ft. Strauss bascule spans and two 70-ft. plate girder tail spans supported on concrete piers and abutments square with the bridge axis. The length of main spans was determined by the Government requirements of two openings 120 ft. wide in the clear at right angles to the river channel, intended to provide for increased navigation after the proposed improvement of the channel by dredging it to a width of 480 ft. and a depth of 24 ft. The bascule spans have two rectangular riveted through trusses 60 ft. apart and 45 ft. deep on centres with trunnion bearings on the abutment piers and standard bearings on the centre channel

HELL GATE BRIDGE, NEW YORK; APPROACH GIRDERS.

MR. GUSTAV LINDENTHAL, CHIEF ENGINEER.



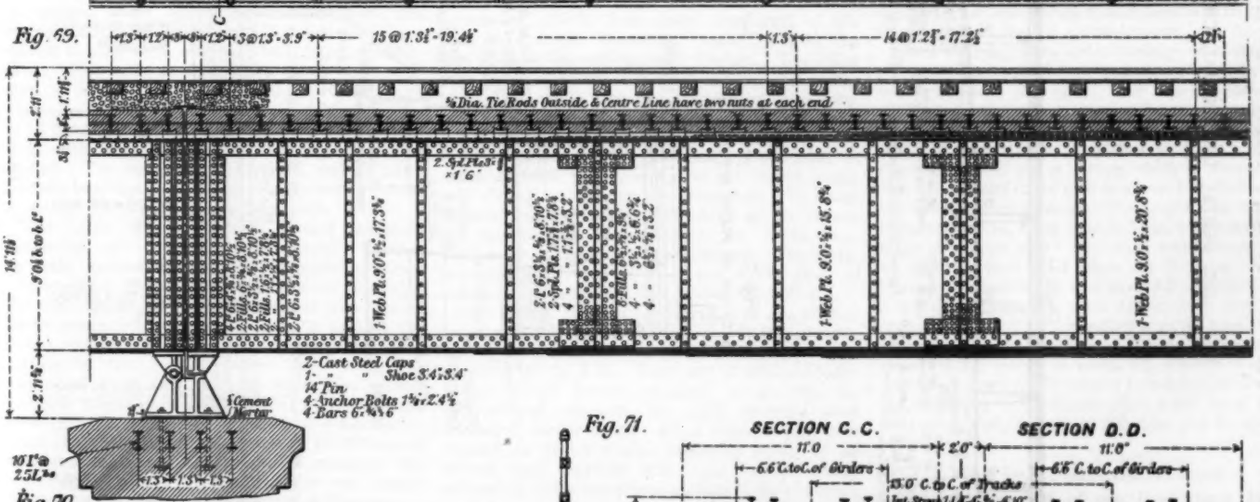
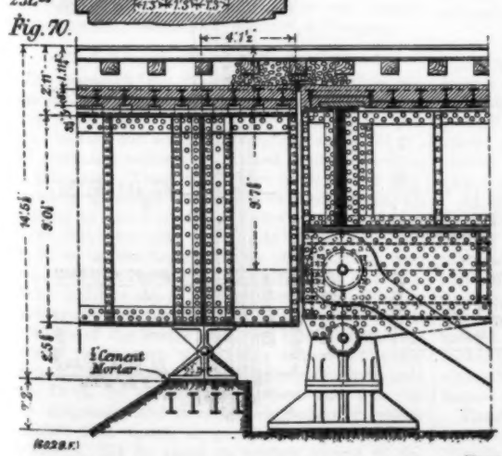
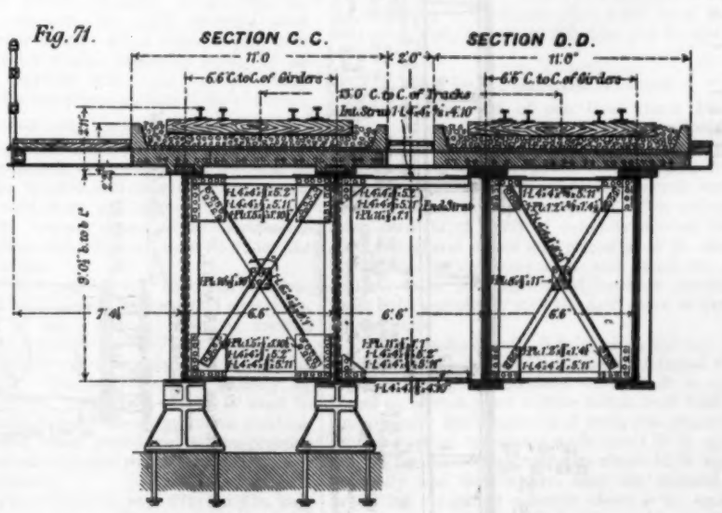


Fig. 69.
15 @ 1'3½" - 19.4"
14 @ 1'2½" - 17'2½"
⅝ Dia. Tie Rods Outside & Centre Line have two nuts at each end.
2-Cast Steel Caps
1- " Shoe
14" Pin.
4-Anchor Bolts
4-Bars
½ Cement Mortar

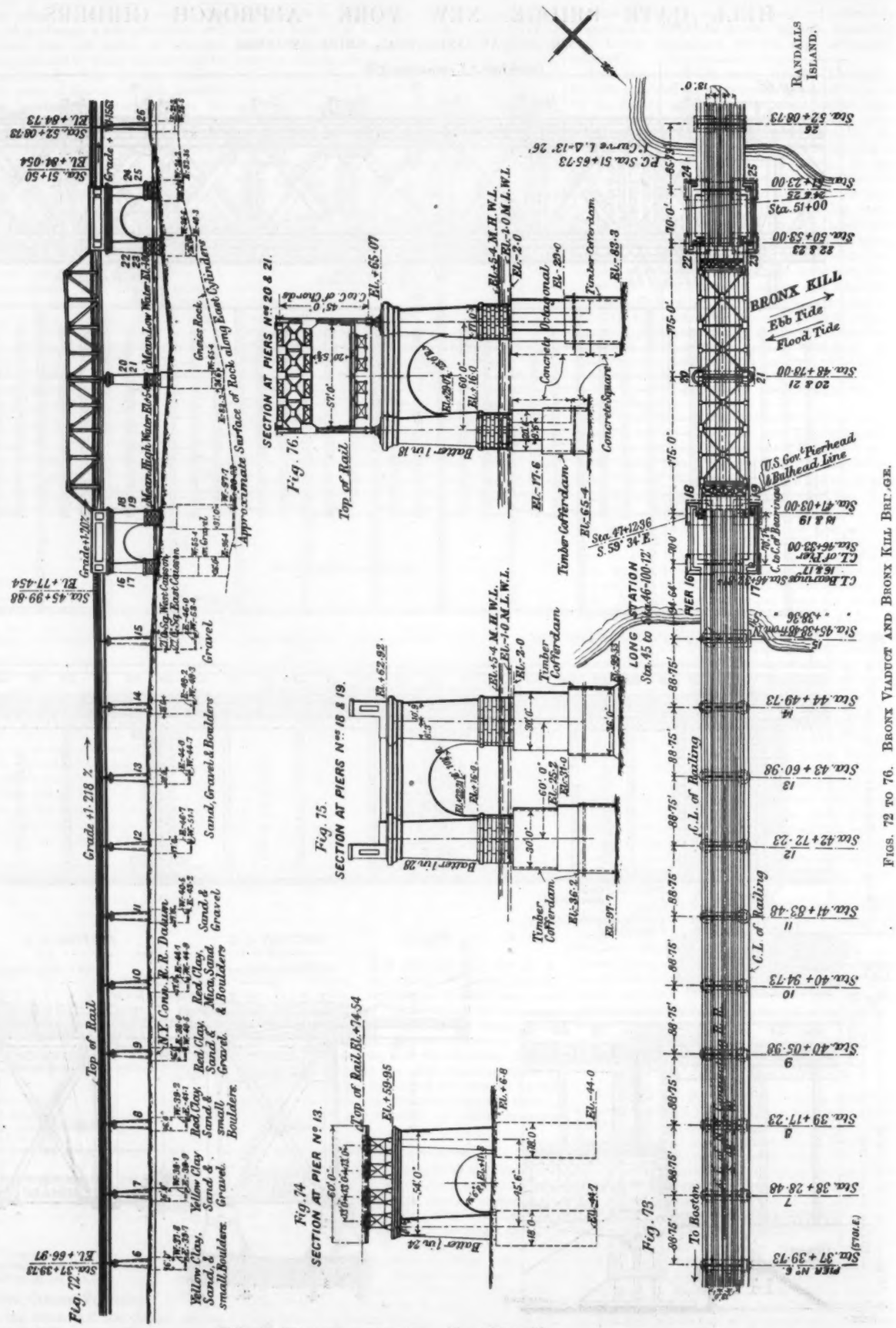




FIGS. 68 TO 71. DETAILS OF APPROACH VIADUCT.

HELL GATE BRIDGE, NEW YORK; APPROACH VIADUCT.

MR. GUSTAV LINDENTHAL, CHIEF ENGINEER.



FIGS. 72 TO 76. BRONX VIADUCT AND BRONX KILL BRIDGE.

pier. The spans have been erected as fixed spans without operating mechanism, which may be added when occasion demands in the future.

Each abutment consists of four rectangular piers connected by longitudinal and transverse arched concrete walls that will ultimately contain the operating machinery. The intermediate pier in mid channel consists of two circular shafts joined by a light concrete arch. All piers have foundations on timber caissons sunk by the pneumatic process to depths of 30 ft. to 105 ft. below high water. The bridge was fabricated by the McClintic–Marshall Construction Company, which also erected it on heavy timber falsework containing 650,000 ft. board measure of timber for each span. The superstructure was assembled by a 50-ton derrick car and locomotive crane. The steel work weighed 3,575 tons and there are 28,300 yards of masonry, the total cost amounting to about 800,000 dols.

Little Hell Gate Bridge.

Little Hell Gate Bridge (see Figs. 77 to 81, on Plate XXXIX), is 1,153½ ft. long and 110 ft. above high water. It crosses Little Hell Gate Channel of the East River, between Ward's Island and Randall's Island, about 1½ miles west of the Hell Gate arch span. The tidal currents are very swift and the channel, only about 15 ft. deep at high water, has a rock bottom and is obstructed by rocks and boulders. Navigation is at present confined to small vessels, and no provision has been made for the passage of high-masted vessels. The bridge has four two-truss deck spans, 264 ft. and 296½ ft. long, that are supported on concrete piers set square at the shore lines and skewed at an angle of 70 deg. The river piers each have two slightly battered cylindrical shafts, 25 ft. in diameter at water line, with their tops connected by an arch with moulded cornice. The end piers have heavy transverse walls pierced with a central arch opening 29 ft. wide and reinforced on each side by two heavy buttresses. Each end of each pier carries an ornamental tower, about 70 ft. high, above the coping of the main pier. All foundations are carried to solid rock, and were built in open cofferdams. The main trusses, 52 ft. apart and 50 ft. deep at centres, have horizontal top chords and parabolic bottom chords made up of a maximum of 13 lines of 16-in. by 2½-in. eyebars, about 38 ft. long, with 16-in. pins. All other connections are riveted. The end bearings are fixed, and all intermediate bearings on the channel piers have movable expansion joints with rockers 24 in. high.

The bridge was erected on framed falsework consisting of double bents placed together to make narrow towers and alternate openings and requiring 360,000 ft. board measure of timber for each span. The foundation piles were braced below water-level to secure stability against the strong current and on account of their small penetration in the rocky bottom. The steel was assembled by a 275-ton three-bent steel gantry traveller running on outside tracks at lower chord level (Fig. 83, Plate XL), assisted by a locomotive crane (Fig. 84). The bridge contains 11,250 tons of structural steel and 25,700 yards of masonry, and cost 990,000 dols. It was fabricated and erected by the McClintic-Marshall Construction Company.

Little Hell Gate Bridge Falsework.

The falsework (Fig. 82, Plate XL) was built in two sections, the lower section consisting of piles capped about 14 ft. above datum or low-water level. The upper section had a uniform height of about 84½ ft., and consisted entirely of framed bents seated on the pile caps. These bents were made in five sets, consisting of centre bents of a uniform height, all reaching to the top of the falsework at elevation about 100, two sets of outside bents, each set 42½ ft. on centres from the axes of the bridge, that were about 26 ft. high and carried the traveller tracks, and two sets of intermediate bents, all in the same transverse planes, with their centres 26 ft. each side of the bridge axis, and that had varying heights to support the bridge trusses at panel points. These bents were all independently framed with 12-in. by 12-in. main timbers and 4-in. by 8-in. diagonals, and were all longitudinally braced together 8 ft. apart, in pairs, making a total of 34 towers, 32½ ft. apart on centres except at the piers where, one tower being omitted, they were about twice as far apart. Because the three intermediate piers were skewed at a considerable angle with the axis of the bridge, the towers adjacent to them, one on each side of each pier, were special towers, each having one centre bent, one outside bent and one intermediate bent. The other towers were regular and were substantially duplicates.

The centre towers, concentric with the axis of the bridge, supported longitudinal plate girder spans carrying at an elevation of 107·12 ft. above the low water a service track, on which the material for the erection of the spans was delivered.

Each line of exterior towers carried two sets, each set containing four 20-in. 80-lb. longitudinal I-beams that served as stringers for the 5-ft. gauge traveller tracks. The intermediate towers carried on each side of the bridge axis a set of eight longitudinal I-beams supporting the dead load of the permanent truss.

During erection the trusses were supported at panel points through their lower chord eyebars, the edges of which rested in the concave upper surfaces of cast-iron webbed pedestals seated in pairs on a grillage of 10-in. by 10-in. timbers, 5 ft. long, transverse to the bridge axis, that were in turn adjustably supported on double pairs of steel wedges driven or slacked by horizontal screw rods. These wedges were seated on 5-ft. by 6-ft. solid timber grillages on the top flanges of the I-beams and provided for settlement, and camber adjustments, and for swinging the assembled bridge trusses.

Eastern Viaduct Bridges.

Several streets intersecting the Long Island Eastern Viaduct are crossed by deck truss-riveted bridges aggregating 2,231 ft. in length. The crossing of Potter Avenue (Figs. 85 to 91, Plate XLI), 80 ft. wide, at an angle of only 19 deg., and a track height of 50 ft. above street level, involved an oblique length of 250 ft. from street line to street line, on the skew, which was bridged by three square-end, 135-ft. deck spans, supported at the ends on concrete abutments, monolithic with the side walls of the embankment viaduct. The other ends of the span are supported on two steel rocker bents, each made with two columns and a double-web cross-girder, 10 ft. deep, weighing 130 tons.

Each span has four trusses, 8½ ft. deep and 13 ft. 9 in. apart on centres. The bearings are fixed on one abutment, pin-connected to the rocker bents, and sliding on the opposite abutment. To avoid stresses due to unequal deflections of the trusses all intermediate floor beams are made non-continuous at the intermediate trusses. The bridge contains 3,722 tons of steel and 4,000 yards of concrete masonry, and cost about 275,000 dols.

The bridges at the other crossings in this viaduct have spans varying from 120 ft. to 160 ft. in length, and are unusually heavy, due to their limited truss depth of 16 ft. 4 in. They are of similar design to the Potter Avenue crossing, except that the intermediate supports are solid concrete piers instead of rocker bents. All of these bridges were erected on heavy timber falsework bents by an 80-ton steel traveller with long double booms advancing on the completed portion of the structure.

Bridge and Viaduct Floor.

In order to procure a more uniform road bed and greater safety in case of derailment or fire, and to diminish noise, impact and cost of maintenance, a solid ballasted floor was adopted throughout, except for the bascule spans, at a considerable greater cost than that of an open-tie floor, for the steel superstructure.

At first a solid treated timber floor was favoured on account of its apparent lightness and cheapness, but in view of the increasing cost of treated timber and the greater durability and fireproofness of steel and concrete construction, the latter was finally adopted. The load is carried entirely by the steel members, and the concrete is used to enclose the latter and provide a continuous platform without reliance being placed on its compressive strength or adhesion to steel rods to resist the heavy impact and stresses.

The floor (Figs. 68 and 69, page 675) has 8 in. long transverse I-beams, 16 in. apart on centres, supported directly on the top flanges of the stringers or track girders and tied together near the bottom flanges with ⅝-in. longitudinal rods, 10 in. apart, passing through the webs. The I-beams are enclosed in a solid mass of concrete, 11 ft. wide and 10 in. thick, made 1 : 2 : 4 with Portland cement, graded sand and broken limestone, 75 per cent. ¾ in. and 25 per cent. screenings, that tested to an average compressive strength of 3,500 lb. per square inch at the age of 28 days. The concrete is reinforced by longitudinal rods resting on the steel beams, and the edges of the slabs are made integral with parapet walls 6 in. wide and about 2 ft. high overall, to retain the stone ballast. At all expansion joints in the steel superstructure the concrete troughs are provided with corresponding expansion joints covered by T-shape steel bars bedded in a thin layer of asphalt. Wooden sidewalks are laid on the I-beams between tracks. The floor construction contains 1½ yards of concrete, 1,200 lb. of steel, and 40 ft. board measure of timber per linear foot of timber, and cost about 53 dols. per linear foot of bridge.

Northern Bronx Viaduct.

Between 138th-street and the Harlem River two of the New York connecting railroad tracks which lie between previously-located tracks of the New York, New Haven and Hartford Railroad are carried on an earth fill about 19 ft. high, contained between two vertical longitudinal concrete walls connected by transverse concrete walls about 20 ft. apart, that distribute a practically uniform foundation pressure of about 1½ tons per square foot on the surface of the wide embankment, 20 ft. high, carrying the original railroad tracks and made of gravel fill containing large boulders. The other two tracks carried at the same elevation entirely outside of the original railroad embankment are supported on an extension of the latter and on an added earth fill retained between concrete longitudinal walls, that on the outside having foundations below the original surface of the ground and the other one having foundations a little below the surface of the old embankments.

Both retaining walls are of L-shape cross-sections with wide horizontal bases, and are stiffened by vertical buttresses, 8 ft. apart, and heavily reinforced with steel rods. The outer wall has a maximum over all height of about 38 ft. and maximum bottom width of about 15 ft. The other wall has a height of about 17½ ft. and a bottom width of about 8 ft. The base of the outer wall is about 7 ft. below the surface of the ground, and is supported on wooden foundation piles, 35 ft. to 45 ft. long, with maximum loads of 20 tons each. The other wall is supported on 12-in. hollow steel piles, 60 ft. long, driven through the boulder fill into hard soil and filled with concrete. These piles were driven with cast steel shoes and loaded to a maximum of 45 tons each. This portion of the viaduct, 1,173 ft. long, contains about 16,000 yards of earth fill, 12,000 yards of concrete masonry, 855 tons of structural steel work, 135,000 linear ft. of timber piles, 8,800 linear ft. of steel piles, and cost about 230 dols. per linear foot of structure.

Long Island Eastern Viaduct.

The southern end of the East River Bridge division of the New York connecting railroad is known as the Long Island Eastern Viaduct, and is made with a novel type of embankment, from 30 ft. to 65 ft. high, with reinforced concrete arches crossing seven street intersections. The embankment consists of a fill of carefully-selected clay, sand and gravel mixed and placed in 12-in. crown layers thoroughly compacted and faced on the vertical sides by longitudinal concrete retaining walls built monolithic with the arch spans at street intersections.

The longitudinal walls, 3 ft. thick at the top, are battered on the outside faces, and are integral with footings of slightly increased width built in open trenches, carried down a little below frost limit in the ground. The longitudinal walls are connected by thin vertical transverse walls about 50 ft. apart and by horizontal 2½-in. tie rods about 10 ft. apart vertically and horizontally, that are encased in protecting masses of concrete about 8 in. square in cross-section. The fill is thoroughly drained through weep holes at the bottom of the walls, and

40–50-H.P. SIX-CYLINDER MOTOR CAR.

CONSTRUCTED BY MESSRS. D. NAPIER AND SON, LIMITED, ENGINEERS, ACTON, LONDON.

(*For Description, see opposite Page.*)

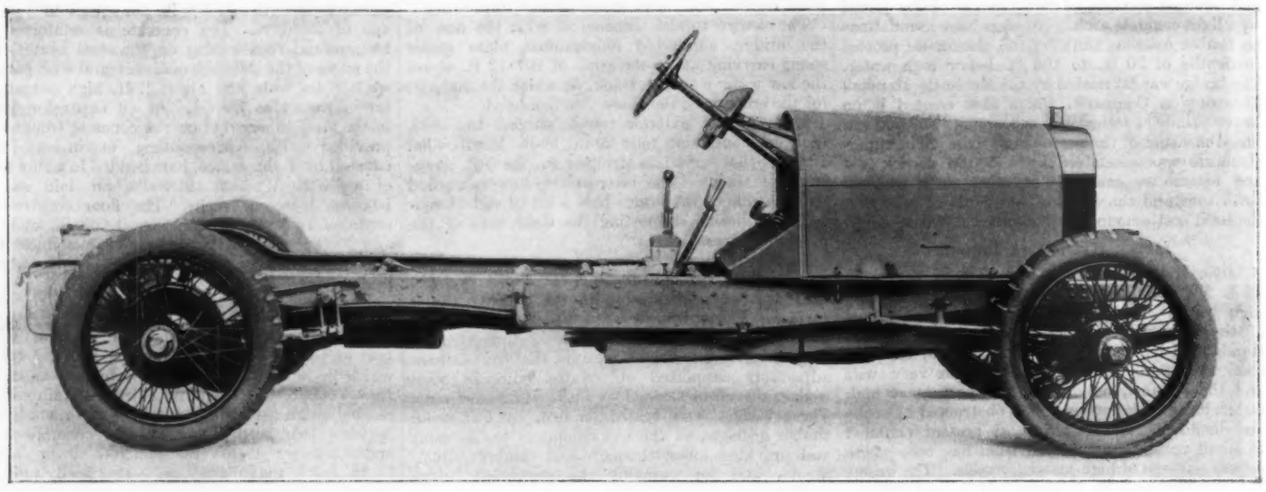


FIG. 1. VIEW OF COMPLETE CHASSIS; OFF SIDE.

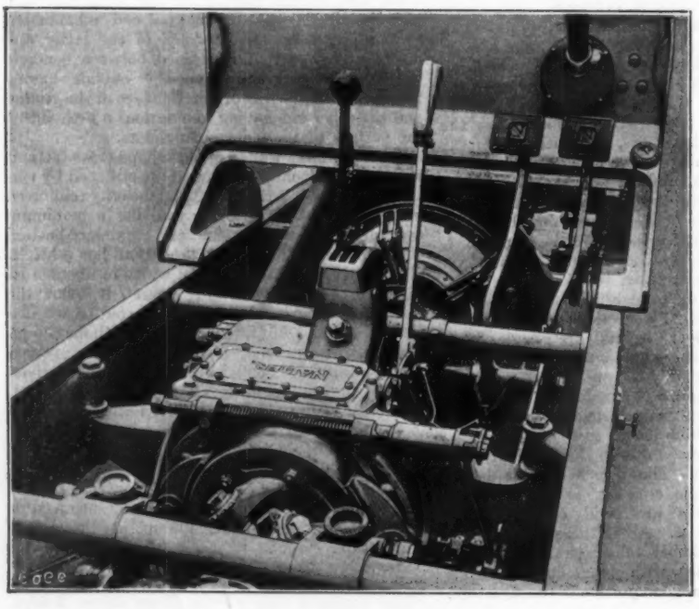


FIG. 2. VIEW OF CHASSIS SHOWING CLUTCH, GEAR-BOX AND BRAKE.

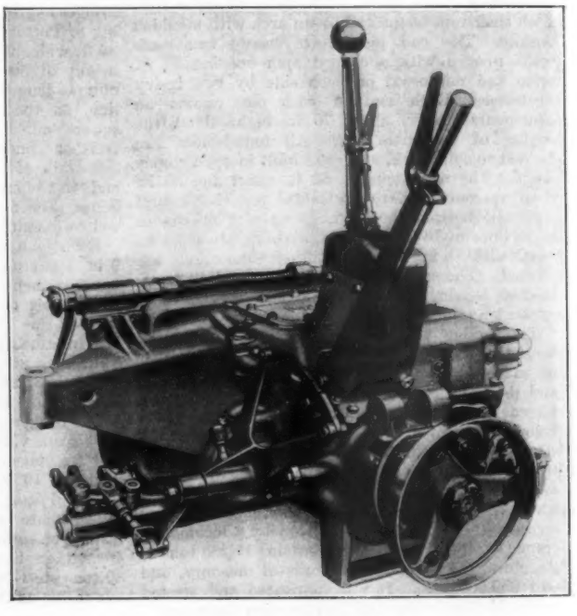


FIG. 3. THE GEAR-BOX AND CONTROL LEVERS

is covered with a cinder bed on which the stone ballast is laid.

The concrete for the viaducts was prepared at ground level in mixers of standard pattern similar to that shown on Fig. 92, Plate XLII. On being discharged from the mixer the concrete passed into a bucket in which it was lifted within the tower to the hopper, and thence into the chutes shown in Figs. 93, 94 and 95.

Fig. 93, on Plate XLII, shows the hoisting towers and steel shoots for conveying the concrete to the arch spans in the Long Island Viaduct; this illustration also shows in the foreground the reinforcement steel assembled for the high retaining wall.

Fig. 94, Plate XLII, is a view of the reinforcement steel for the arch spans in the Long Island Viaduct being assembled, with the distributing chutes for the concrete overhead.

Fig. 95 shows the reinforcement steel and the lower section of the forms for the concrete piers for the Randall's Island Viaduct. The tower shown in the illustration, for raising the concrete to the high-level chute, is 214 ft. in height, and in this case it is interesting to note that the chutes are trussed.

This embankment, which is about 3,500 ft. long, including the street arch spans, contains about 70,000 yards of concrete masonry, 160,000 yards of earth fill, and 1,000 tons of steel reinforcement. The cost, inclusive of the tracks, was about 470 dols. for a height of 65 ft. and 280 dols. per linear foot for a height of 35 ft., which was estimated to be cheaper than the regular steel viaduct for heights of less than 65 ft.

EASTERN VIADUCT TRAVELLER.

The truss bridges—one of these is shown in Fig. 85, on Plate XLI—in the Eastern Viaduct were fabricated and erected by the McClintic-Marshall Construction Company, and erected by them with a steel mule traveller with a steel frame platform, 28 ft. wide and 43 ft. 2 in. long, supported on six wheels on a 19-ft. 6-in. gauge track. The transverse lower beams supported two electric hoisting engines, and were floored with 2-in planks. At each front corner of the traveller there was a steel derrick with 70-ft. boom vertical mast and an inclined leg pin connected to the rear end of the platform. The tops of the masts were connected by a horizontal transverse strut. The track rails were laid on the centres of two lines of permanent longitudinal stringers, and when the traveller was in service care was taken to bunch the 8-in. permanent deck floor beams as close together as they could be placed, so as to secure a group of 14 beams to distribute the maximum 100,000-lb. live load on one wheel underneath the derrick mast.

40-50-H.P. SIX-CYLINDER MOTOR CAR.

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Fig. 4.

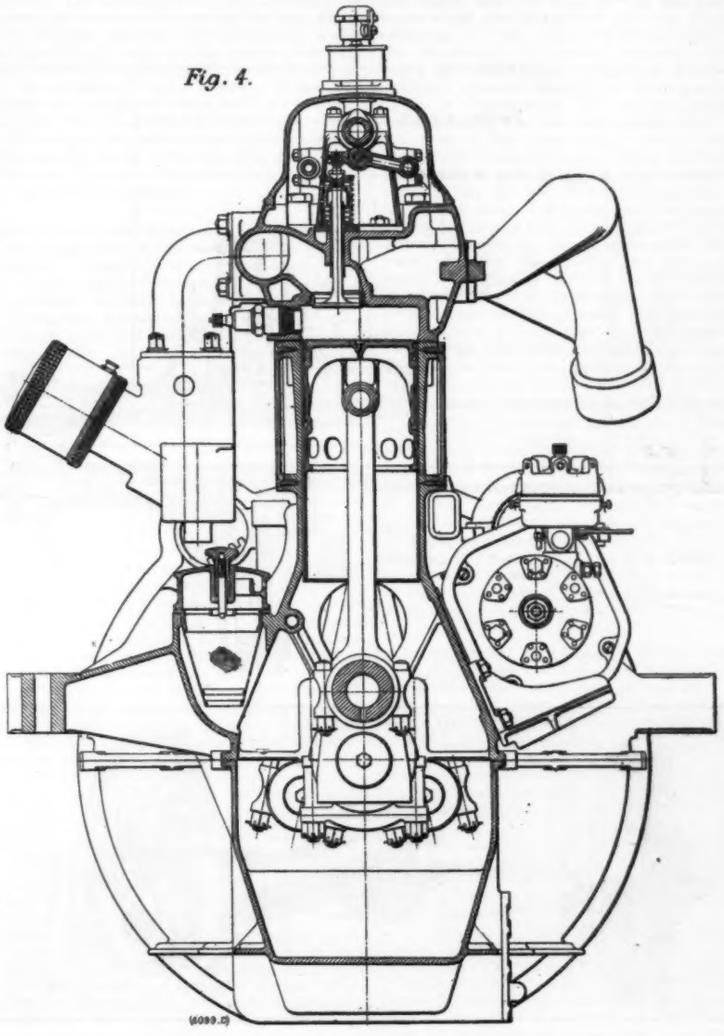
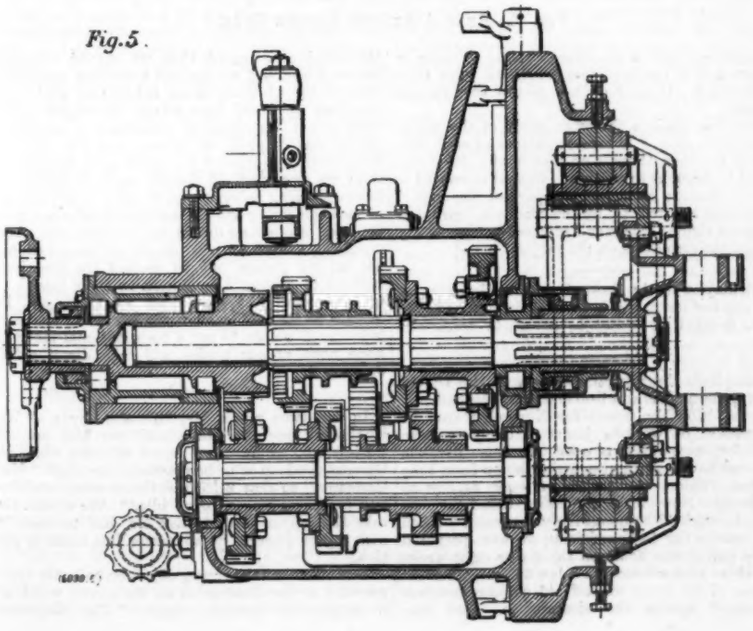


Fig. 5.



40-50-H.P. SIX-CYLINDER NAPIER MOTOR CAR.

Among the high-powered and first-quality cars shown at the Olympia Motor Exhibition, which closed last Saturday, the six-cylinder model of Messrs. D. Napier and Son, Limited, of Acton, London, W., took a high place. Messrs. Napier's name has for long been associated with the six-cylinder car, and with an article of the best class, so that their new model, incorporating the experience of more than four years of aero-engine work, is of necessity an object of considerable interest. The firm's policy now is to build one model only—of 40-50-h.p.—and in the illustrations on this page and pages 678 and 680 we give various views and details of the engine and chassis of the new design. The wheel base of the car is 11 ft. 5 in. and the track 4 ft. 8 in. The overall length is 15 ft., and the overall width 5 ft. 7½ in. The ground clearance is 8 in., but for overseas use a minimum clearance of 9½ in. can be given. The car is arranged to be fitted with various bodies, providing from four to six seats.

One of the points which has received special consideration in the design of the chassis is that of weight reduction. Aero-engine experience has, of course, been of much assistance in this connection in helping towards an increased ratio of power to weight. The engine fitted to the new Napier car has a brake-horse-power of 80, and the weight of the chassis is 25 cwt. This gives a weight of 35 lb. per horse-power developed. This question of weight reduction naturally has a direct bearing on the wear of tyres and the consumption of petrol and oil. In the case of the Napier model the concomitant increase of speed, particularly on hills, has, we think, been looked upon as an important consideration. The chassis weight given above shows a reduction of some hundredweights as compared with Napier pre-war models. The general appearance of the completed chassis is well-shown in Fig. 1. The frame has pressed steel side members of deep section, and is designed to be entirely free from sharp bends. The construction is very stiff, as is so essential if strains and stresses are not to be set up in the body work of a high-powered car of this class.

Views of the controls and gear-box are given in Figs. 2 and 3, but before referring to these in detail we shall deal with the engine of which a cross-section is given in Fig. 4, on the present page. The construction is unusual. The six cylinders, which are each 4-in. bore by 5-in. stroke, are of aluminium with steel liners, a common casting forming the cylinders and the upper part of the crank-case. The cylinder head is detachable, and, as will be seen from the figure, overhead valves are used operated from an overhead camshaft. The valves are made from non-corroding steel, and the valve seats, of the same material, are screwed into the cylinder head. As can also be seen from the figure, the cylinder jackets are formed by cover plates screwed to the casting. This form of construction facilitates the foundry work, as we have already referred to in some of our earlier articles dealing with the show. The pistons are of aluminium, and are lightened by drilling holes through them below the lower ring. The camshaft is driven by skew gear through a vertical shaft, which is enclosed in a tubular oil-tight casing. All working parts of the engine, indeed, are enclosed, a cover being provided for the valve-operating gear, as is shown in our figure.

Water circulation by a centrifugal pump and force feed lubrication is used. Ignition is by high-tension magneto and alternatively from a battery, which is also used as a lighting battery in conjunction with the electric lighting set. An induction coil is fitted for use when battery ignition is employed. The pump, lighting dynamo and magneto are arranged in one line of shaft on the near side of the engine, a position in which they are very accessible. The lighting dynamo and starting set are of C.A.V. make. The carburetter is of the S.U. type, with special Napier details. The carburetter has two controls, one from the steering wheel, which is mainly used for work in traffic, and the pedal control. This latter actuates a movable jet and permits the mixture strength to be varied over a wide range.

The clutch is of the single-plate type, and connects to the gear-box through the usual universal coupling. The gear box, which is shown in position on the chassis in Fig. 2, and separately in Fig. 3, is carried on a three-point suspension from one of the round cross-members of the frame and from two side lugs, which pivot to brackets carried by the main frame side members. The box is also shown in horizontal cross-section in Fig. 5, annexed. The gears, as will be seen, are of the sliding type. The most notable novelty in connection with this gear box is that a central plate change-speed arrangement has been adopted. This is a new feature of design that we have already referred to more than once in our articles dealing with the Show. The advantages, briefly, are that the connection between the control levers and the gear box is made much more rigid, as compared with mounting the gate and levers

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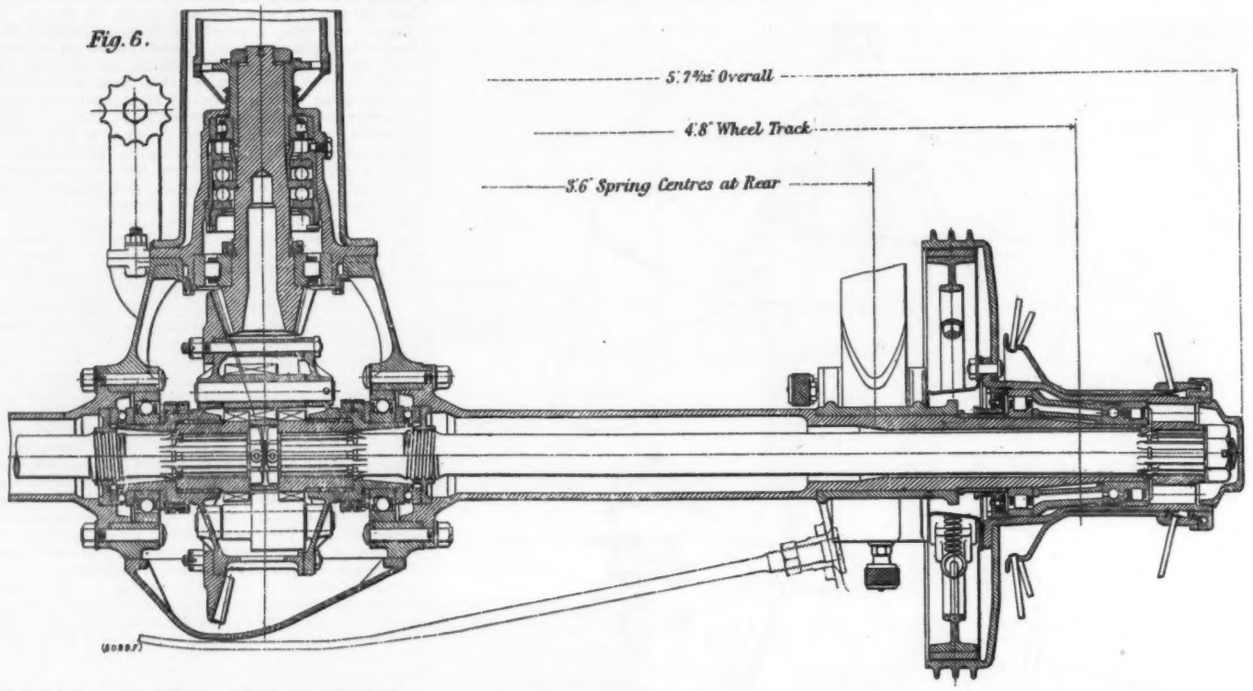
Fig. 6.



on one of the side members of the frame. With the central gate, the connection is unaffected by distortion of the frame, which may take place when the car is manœuvring on uneven ground. Another point is that with the levers placed between the driver and the other passenger on the front seat, easy ingress and egress may be made to the driver's seat without disturbing the passengers.

Immediately behind the gear box, on the main shaft, there is a pedal-operated brake of the external-contracting type. It can be seen in Figs. 2 and 5. Immediately behind the brake the anti-rolling device attached between the head of the torque tube and one of the cross-members of the frame is fitted. This device can be seen in Fig. 7, annexed, but it was illustrated in considerably more detail and described in our issue of last week, and it is not necessary that we should now deal with it again. The back end of the torque tube, the differential and the rear axle are shown in cross-section in Fig. 6, on the present page. This shows the details of the construction well, and will require little explanation. The road wheels are of the Rudge-Whitworth detachable wire type. Each carries a ribbed drum for an internal-expanding brake, which is operated by hand lever. Cantilever springs are fitted to the rear wheels, and are, of course, reinforced by the anti-rolling device we have already dealt with. The front wheels have semi-elliptic springs, and the steering is by worm and sector.

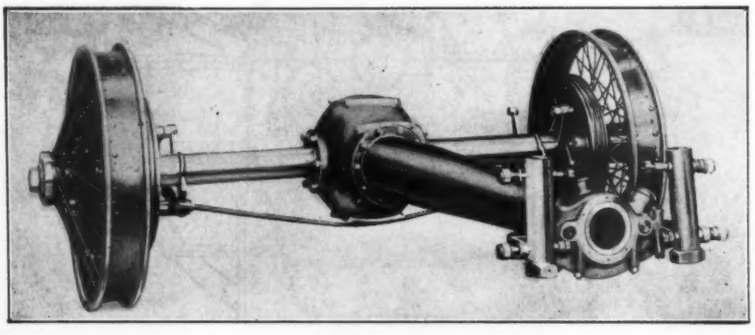


FIG. 7. REAR AXLE AND TORQUE TUBE.

INDUSTRIAL NOTES.

EIGHT weeks ago to-day the moulders decided to act on their own initiative and strike, and during that period their drastic action has caused more or less chaos in all industries in which iron is the most important factor. Those indirectly affected are victims with whom genuine sympathy is felt, but the moulders themselves and their wives and families are feeling the pinch very severely. Their funds are run dry, and urgent appeals are being made in different directions for help.

In an interview with one of the chief officials of the Friendly Society of Ironfounders, a representative of the *Sheffield Daily Telegraph* learned that they had been anxious all along to negotiate and were still anxious to meet the employers at any time in order to bring about a settlement.

What is the position of the employers? It is as it was. They are simply helpless in the matter. The moulders broke away from the other unions, and came out on strike of their own accord. The fact should not, however, be lost sight of, adds the Sheffield journal, that the masters told them when they downed tools that if they came back to work they would treat them on the fairest grounds possible.

The engineers have a 5*s.* award coming to them in December, and if the moulders return to work they will be included. If they do not return they cannot participate.

One who has made a thorough study of the whole vexed question says, "If representatives of each side could meet together, there is no reason why the strike should not be brought to an end. All that is wanted is a more conciliatory spirit on the part of the men."

The meeting referred to by the Sheffield journal is to take place shortly, the men's representatives having approached the employers on the subject.

The bricklayers in the Scottish steel works, who, as stated in our last issue, had been on strike for a number of weeks, decided by ballot to return to work last Monday.

Mr. John Hill, the general secretary of the United Society of Boilermakers and Iron and Steel Shipbuilders, states in his monthly report for November that:—"The question of working hours is likely to give trouble before the winter is over. In some districts our members have had shorter winter hours from time immemorial. Hours in mid-winter were as low as 40 per week. Now they are being asked by the employers to work 47 hours all the year round. When we went out for the 44-hours' week we were prepared to give up our winter hours on the six or eight weeks on which these winter hours fell below 44, but, when the compromise of 47 hours was offered us, our members went strongly against the compromise. Last year the employers agreed that we should continue our winter hours, and we had the hope that we would have secured the 44-hours' week before this winter, and in this way we would have solved the winter hours problem; but the lack of steadfastness among many unions has delayed our hopes, and left us in a less favourable atmosphere for securing a 44-hours' week than we were just 12 months ago. I believe the 44 hours is being taken up unofficially. The rank and file of the engineering and shipbuilding trades are getting a bit tired of our long drawn-out negotiations. Honestly speaking, I think we need ginger on the question, but I ask all the groups not to neglect the constitutional method of getting a resolution in their branch. This is more than a boilermakers' question, and it will require resolutions in the branches of all trades in the industry if we are to get a constitutional move on. I hope none of our trades will take direct action on January 1."

In the same report Mr. Hill also says:—"We are blockading our own trade with our best markets in Europe, and we have just issued an order which allows German goods to come here without the mark "Made in Germany," so that British workmen must work harder and for lower wages, or go idle." We should like to take this opportunity to ask Mr. Hill to state in his next report whether he advocates free trade or protection.

But what we take strong objection to in the report in question is the illustration on the cover, which shows a shipbuilder forming, alone, "The Keystone of

Industry during the War," the illustration being a reproduction of one published in an American journal. It is quite true that the craftsmen employed in shipbuilding did yeoman service during the war; but this was the case with all other craftsmen and women volunteer workers. The illustration not only ignores these, but it ignores also—as is unfortunately the very general custom in biassed quarters—the invaluable service rendered by all brain workers, who, among their other activities, undertook the design of new ships and the carrying out of new and rapid processes of manufacture, designs and processes which the "shipbuilder" had simply to follow to make a successful job. Moreover, with the ships, but without brave men to navigate them, this country would have been in a sorry plight. The "Keystone," therefore, is not one man, but a whole legion of workers of all classes.

We give below a few figures of the ballot on the scheme of amalgamation for unions connected with the engineering and cognate trades:—Ballot papers issued, 313,727; ballot papers returned, 177,173; votes in favour of scheme, 163,181; votes against the scheme, 13,992; percentage of members voting, 56½; percentage of members voting in favour, 92½; percentage of members voting against, 7½. The following organisations have recorded votes in favour of the scheme:—Steam Enginemakers, United Machine Workers, Amalgamated Smiths and Strikers, North of England Brass Turners, and London United Metal Turners. Other returns are to follow.

Speaking at a meeting of railwaymen at Bristol last Sunday, Mr. J. H. Thomas, M.P., made the following statement:—"Since the strike we have been reviewing the whole situation with the Government, and a definite and complete offer is now before us. I do not want it mixed with our negotiation on wages. I want to make it perfectly clear that our negotiations on standardisation are being dealt with by the Executive, independently of the new machinery. Now, it is first proposed to set up a joint board on the railways—not on each railway, not on each system, but a board composed of five general managers and five from the Associated Locomotive Engine Drivers and Firemen and from the N.U.R. Three of these latter five will represent the N.U.R. and two will act for the Associated Locomotive Engine Drivers and Firemen. These ten will be charged with the responsibility of conducting negotiations in connection with the conditions of service. Nothing whatever will be exempted from their consideration. That is to say, we have got over the old 'boggle' limiting ourselves to hours and wages. The ten—five from each side—will have plenary powers, but only in the sense that the men's side would be subject to their Executive Committee. In the event of their failing to agree, they will have the right to call in another body. It is no use disguising the fact that in the event of a railway dispute there is a great public opinion that ought to be considered, and in the event of a failure on the part of these ten—five from either side—they will be able to refer the matter to another body of twelve—four from the men, four from the railway companies, and four from the public. But the working men are as much the public as the capitalists are, and, therefore, as regards two of the four, one will be a trade unionist not connected with the railways, and another will be a representative of the great co-operative movement. In other words, you will be able to bring to the review of your case a tribunal on which the public will be represented. There will be an independent chairman. We want you, however, clearly to understand that while they will be in a position to give recommendations and to advise and suggest, neither body will have the power to take away the right to strike so far as the men are concerned. But obviously we would not strike while a matter was being considered. . . ." Mr. Thomas added that, in addition, there would be set up local machinery to enable the men locally to meet an equal number of the managers and deal in the same way with all local grievances that might arise. He expressed the opinion that the new arrangements, if properly worked in a fair and genuine spirit on both sides, would do much to make trade unionism a means of improving the men's condition and to ensure smooth working on the railways of the country.

Lord Gainford, speaking last week at a luncheon given by the Mining Association of Great Britain, made a strong protest against the Bill which the Government propose to introduce to limit profits in the coal trade to 1*s.* 2*d.* per ton for the current year. The proposal, which, he said, was without precedent and quite unjustifiable, was put forward by the Government in accordance with the pledge given in regard to the recommendations of the Sankey Report of March last. With regard to these recommendations, Lord Gainford pointed out that the witnesses before the Sankey Commission were instructed to confine their evidence to the questions of hours and wages, and the proposal to limit profits to the above-mentioned amount was made on the assumption that strikes and absenteeism would cease, and that the output of coal would reach 250,000,000 tons per annum. Several other recommendations in the report, outside the question of hours and wages, had not been carried out, and the coal trade could see no reason for the Government's adherence to the recommendation with regard to the limitation of profits, especially as it was based on assumptions afterwards falsified. Lord Gainford objected strongly to the figure of 1*s.* 2*d.* taken as representing the average profits in the coal trade for the last five years before the war, but even if the figure were correct, the cost of sinking and equipping a new colliery was now two and a-half times as great as in 1914, so that a profit of 1*s.* 2*d.* a ton before the war would be equivalent to about 5*d.* a ton now. Obviously, he continued, colliery owners, under any such limiting scheme, would have no interest in reducing costs or undertaking development work. For the current year the effect of the Bill would be to deprive the coal trade of about one-half its pre-war profits of 25,000,000*l.*, which was earned at a time when capital generally was receiving a much lower rate of interest than it could now command. The present high price of coal, Lord Gainford said, was due to high costs caused by the raising of the minimum wage by the Government. In his county the minimum was 13*s.* 8*d.* a shift, and 60 to 70 per cent. of the men were producing less than 2 tons per shift. The remainder, working in similar places, had been getting over 4 tons per shift at piece rates. The trade, he said, was quite prepared to consider how far profits might be better distributed among the trade as a whole, so long as such control is retained as is necessary in connection with the limitation of prices in the interest of the home consumer, but he considered it unjust to impose a special limitation of a very harassing character on one industry alone. He therefore sought the support of those interested in all other trades and industries in opposing the proposed Bill.

In Parliament last Monday, on the order for the third reading of the Industrial Courts Bill, Mr. A. Henderson said that Labour specially welcomed the alternative forms of arbitration embodied in the Bill. The decision as to the composition of panels had also given satisfaction. Mr. Clynes stated that, defective as the Bill was, he hoped employers and employed would make the fullest use of its provisions. He also hoped that due regard would be given to the claims to representation of women and less skilled and semi-skilled workers, who had not previously had a place on panels and Courts of Arbitration. In the course of his reply, the Minister of Labour, Sir R. Horne, said he was ready to agree to the way in which the panel system should be dealt with; he would also consider all other suggestions. He did not anticipate any difficulty in arriving at an agreement on those topics. He agreed that the great object they had in view was to get rid of the causes of difference, rather than to rely entirely upon a means of settlement when those differences had arisen. In the meantime, they had to recognise that causes of difference did arise and disputes afflicted the country from time to time. He did not make any great claim for the measure. It was in no sense epoch-making. He relied rather on the goodwill, the desire to co-operate which had been evidenced in committee, and he wished to express his personal gratitude for all assistance granted in giving the Bill its final shape. He realised that the goodwill and co-operation of the trade union movement were essential to the success of the Bill and of other measures of a similar character. The Bill was a modest and simple measure, not to enforce peace, but to secure peace. We wanted to settle industrial disputes by humane and reasonable methods, and it was because he believed that the Bill would do something to foster and encourage a spirit of arbitration rather than a spirit of controversy that he asked the House to read the Bill a third time. The Bill was then read the third time.

Last Monday, the Court of Arbitration issued the following awards on dockyard workers' claims:—

A claim was made by the Federation of Engineering and Shipbuilding Trades and the Amalgamated Society of Engineers for a substituted minimum base rate of 43*s.* a week, plus 28*s.* 6*d.* war wage, 12½ per cent., and 15*s.* a week, applied for on behalf of the artisans. The court decided that the claim for a minimum base rate of 43*s.* for all grades was not established. But they approved the offer of the Admiralty to increase the base time rates by 2*s.* a week, to take effect from April 6; for shipwrights, fitters, boilermakers, founders, pattern makers, joiners and plumbers, painters, bricklayers and masons, and other classes of workers. The court also awarded a further war advance of 5*s.* a week to men over 18.

A similar claim was made by the Workers' Union for mechanics engaged in hose making in the ropery and as sailmakers in the dockyards. The court decided that the claim for a minimum base rate of 43*s.* was not established, but here again they approved the offer of the Admiralty to increase the base time rates by 2*s.* a week, and they awarded a further 5*s.* war advance.

The Ship Constructors and Shipwrights' Association made a claim that the average outside repair rates, namely, 4*l.* 3*s.* 6*d.* a week, including war advances and bonuses, should be paid retrospectively from January 1 last. The court decided that the claim was not established, but they approved the offer of the Admiralty to increase the base rate from 39*s.* to 41*s.*, to take effect from April 6.

The associated iron moulders of Scotland decided on a record vote to hand in notices last Wednesday to cease work on Wednesday, the 26th inst., to enforce the demands for an increase of wages of 15*s.* per week for men and 7*s.* 6*d.* for youths under 18. There voted for a strike 3,469, and against 2,638. In a circular issued to the men it is stated that the cause of the strike is the allegation that Scottish firms have of late been forwarding standardised patterns to English firms where the men are on strike.

Mr. T. Richards, M.P., general secretary of the South Wales Miners' Federation, denies the statement attributed to Mr. Mills, chairman of the Ebbw Vale Company, that South Wales miners are capable of earning to-day from 1,000*l.* to 1,200*l.* a year, and that Ebbw Vale miners earn an average of 800*l.* Mr. Richards added that nothing like such wages had ever been received in the coalfield. In other quarters, however, it is well established that miners are now earning at the rate of over 500*l.* a year.

"THE RADIO REVIEW."—We welcome *The Radio Review*, a new Monthly Record of Scientific Progress in Radiotelegraphy and Telephony, the first number of which was published last month. Most people are not in favour of a further increase in the number of technical and scientific journals; the more they increase, the more difficult it becomes to keep *au fait* in any branch of science. If exceptions be justified, however, the right of existence cannot be denied to an English journal exclusively devoted to radiotelegraphy, which has undergone a most remarkable development during the past few years and has a very extensive literature, so far scattered through a large number of publications, partly difficult of access. The new review is to cover the physical and mathematical sides of the problems; engineering problems, unless of a special kind, will not come into the direct scope of the journal. The first number contains in its 52 pages, large octavo, articles by A. E. Blondel, on Goniometric Functions applicable to Directive Aerials, and by W. H. Eccles, on the Internal Action of the Triode Valve, in addition to a long report on the discussion on Radiotelegraphy by the British Association at Bournemouth. A further essential and useful part of the journal is the Review of Radio literature giving illustrated abstracts of papers and patents, as well as reviews of books. The editor, Professor G. W. O. Howe, D.Sc., M.I.E.E., and his assistant, Mr. Philip R. Coursey, B.Sc., A.M.I.E.E., are, we need hardly say, well known as original workers in their subject. The journal is published by the Wireless Press, 12 and 13, Henrietta street, W.C. 2, at 2*s.* 6*d.* per number, the annual subscription being 30*s.*

WAR PRODUCTION OF INTERNAL-COMBUSTION ENGINES.—Some interesting figures relating to the production of internal-combustion engines by British manufacturers during the war are given in Dr. T. Blackwood Murray's presidential address to the Institution of Engineers and Shipbuilders in Scotland, which was read on the 18th inst. From figures supplied by the Ministry of Munitions, and quoted by Dr. Murray, it appears that the total horse-power of aero engines manufactured between August, 1914, and the end of 1918, amounted to no less than 7,094,000, and more than half of the total, viz., 4,143,000 h.p., was turned out in the last year of the war. Between August, 1914, and December of that year the output was only 12,000 h.p., and for 1915, 1916 and 1917, the outputs were 195,000 h.p., 771,000 h.p. and 1,973,000 h.p., respectively. The data relating to engines for mechanical transport purposes are not so complete, as they are only given from September, 1916. For the four months of that year the output amounted to 137,000 h.p., and the figures for 1917 and 1918 are, respectively, 683,000 h.p. and 662,000 h.p. The production of these engines for the war period prior to September, 1916, probably amounted to about 750,000 h.p., so that the aggregate production for the whole of the war would be 2,232,000 h.p. The manufacture of "tank" engines was commenced in 1916, in which year the production totalled 16,000 h.p., while in the two following years the production was 133,000 h.p. and 191,000 h.p., respectively. The total production of tank engines thus amounts to 340,000 h.p. From these figures it appears that what may be called small internal-combustion engines aggregating nearly 10,000,000 h.p. were made during the war for the three uses mentioned above, and as many more must have been employed for lighting and pumping sets, and other work, the complete total was considerably greater. It may be interesting to add that at the conclusion of hostilities 62,000 motor lorries, 28,000 motor cars, and 33,000 motor cycles were in the possession of the British War Department.

AIDS TO AERIAL NAVIGATION.

An instrument which appears to be of considerable service to pilots engaged in cross-country flying has recently been put upon the market by Messrs. Edward Stanford, Limited, of Long Acre, London, W.C. 2. By the use of this instrument it is an extremely simple matter to ascertain the correct compass course to be steered for any aerial journey, provided that the velocity and direction of the prevailing wind be known. At the same time the speed of the machine relatively to the earth is given by the instrument, so that the time required for the journey can be obtained by mental arithmetic. Other similar problems depending upon the solution of the triangle of velocities can also be dealt with by the instrument in a manner which will be readily understood when its general principles have been explained.

The instrument, which is the invention of Captain Angus, R.A.F., and has been well tested under service flying conditions, is shown in use in the accompanying illustration. It is constructed of transparent celluloid, and comprises a protractor, about 5 in. square, with a movable central disc, a radial arm 11 in. long, and two other arms, one of which can slide along the long radial arm, while the other is provided with a longitudinal slot through which the central pivot of the protractor passes; all the arms carry scales divided in knots and miles per hour. To use the instrument the protractor is placed on a map with its centre over the point of departure for the proposed journey, and with the arrow, visible in our illustration, pointing true north. A parallel rule attachment is provided, as shown, to enable this adjustment to be made easily by means of the meridian lines on the map, and discs of glass paper are fixed to the under surface of the protractor to prevent it from slipping. The central disc, which is marked similarly to a compass card, is then turned through an angle corresponding to the magnetic variation of the locality, and the long radial arm, which is called the track scale, is adjusted so that its working edge, *i.e.*, the edge which, if continued, would pass through the centre of the protractor, lies along the course it is desired to make good. A silk cord attached to the centre of the protractor, and having a pin at its outer end, is provided, and this cord can be used to mark the desired course if the track scale is not long enough to reach the destination on the map. The next step is to set the arm carried by the track scale in the direction of the prevailing wind, and, for this purpose, the wind scale, as it is called, has a small compass disc formed at its inner end. The wind scale is turned so that the given wind direction marked on the disc, points to the true north as shown by any convenient meridian line, and clamped in this direction by means of a screw, but the arrangements are such that the scale, although fixed in direction, is still free to slide laterally along the track scale. Small holes are drilled in the wind scale at each division, and, after placing a pin carried by the third, or air-speed, scale in the hole corresponding to the given wind speed, the wind scale is moved along the track scale until the central pivot of the protractor marks the known air speed of the machine on the slotted air-speed scale. An accurate triangle of velocities has then been formed by the working edge of the track scale and the centre lines of the wind and air-speed scales, and the direction of the latter, as shown by the protractor, gives the compass course to be steered. The ground speed of the machine is given by the distance between the centre of the protractor and the pivot of the wind scale measured along the track scale, and the latter is so arranged that the reading is taken between the two points of the slider, which can be distinguished in our illustration on the left-hand side of the wind compass disc.

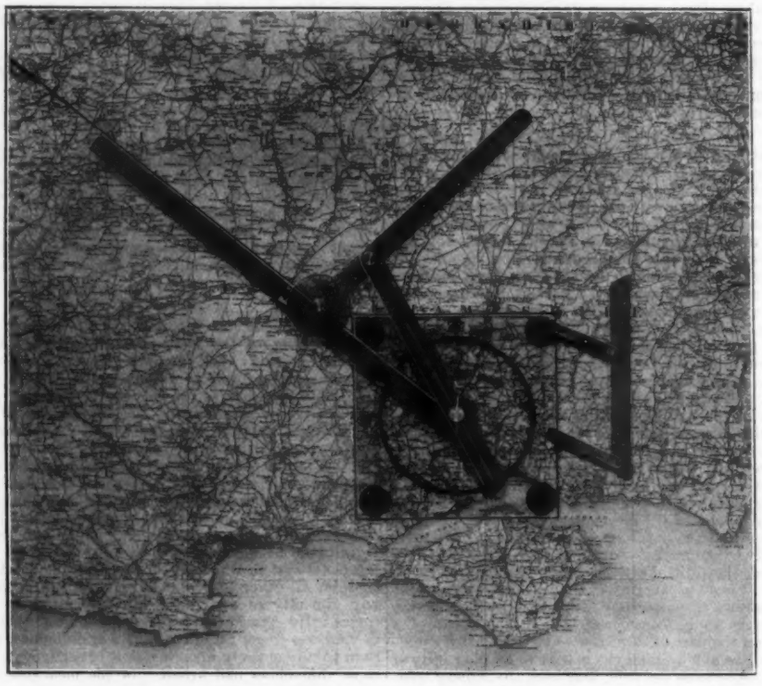
The instrument illustrated has been arranged for a flight from Southampton to Bath in a machine having an air speed of 100 m.p.h. with a wind blowing at 40 m.p.h. from the north-east. Taking the magnetic variation as 18 deg. west of north, the compass bearing of Bath would be 34 deg. west of north, and, if there were no wind, the course steered would be 326 deg. Readings taken from the instrument show that, to allow for the wind, the course steered should be 350 deg., or 10 deg. west of north, and the speed of the machine over the ground would be about 95 m.p.h. These readings, it may be noted, are in reasonably good agreement with results obtained by ordinary geometrical construction. The compass course, determined as above explained, must, of course, be corrected to allow for deviation due to the magnetic properties of the aeroplane. This allowance is usually made, while flying, from a table prepared for the particular machine, but, if preferred, it can be made before leaving the ground by finding the direction of the machine's head very roughly, say, within 20 deg., and adding (or subtracting) the deviation for this direction to the easterly or westerly variation when setting the protractor. It is perhaps hardly necessary to point out in concluding our account of this instrument, that the operations, which are somewhat complicated to explain in words, are extremely simple to carry out in practice. The required results can be obtained in a very few minutes with the actual instrument. At the same time it will be obvious that, to obtain a high degree of accuracy, it is essential that the slider carrying the wind scale should be a very good fit on the track scale. In the instrument we have examined, which was one of the first batch constructed by Messrs. Stanford, there is certainly room for some improvement in this respect, but doubtless this matter will receive attention from the makers.

Another device of interest to aviators is a method of map mounting designed by Mr. N. G. Tunmer, while serving with the Flying Corps in France. The advantage of Tunmer's method of mounting is that the pilot is enabled to carry a map of a large area of country in such a manner that it can be used with the minimum amount of handling—a feature which is of considerable importance in view of the fact that the pilot's hands are usually very fully occupied.

The principle of the method is that a long strip of map, covering, say, 100 or more miles of country in the north-south direction, is taken and cut into a number of narrow strips in the east-west direction. These strips are mounted on linen and folded after the manner of accordion pleating. In the fold, between the alternate strips, a linen tab is fixed, and the section so prepared is attached to a flat holder which can be slung round the pilot's neck by means of a strap and so carried in a convenient position for use. The map section is attached by two press studs at each end to the top and bottom edges of the holder, and is prevented from unfolding by a pair of narrow elastic bands which are passed round the back of the holder and over the map. The size of the holder, it should be mentioned, is such that four strips of map are exposed to view at the same time.

The method of employing these maps is most easily explained if we first consider the case of a pilot starting from a point on the extreme south of the map on a journey due north. For this journey the first four strips of the southern part of the map will be exposed to view and the remainder will be folded up under the fourth strip along the upper edge of the holder. When the journey has proceeded sufficiently to bring the pilot over some point in the fourth strip he pulls the tab between the second and third strips towards him, and, by so doing, folds up the first and second strips and exposes the fifth and sixth to view. It should be noted that the third and fourth strips are still visible, so that the pilot need never lose sight of his position on the map. The procedure explained above is continued until the whole length of the map has been covered, when, if the journey is not completed, a new section of map must be fitted into the holder.

Although we have so far only considered a journey towards the north, the utility of the system is by no means confined to this one direction. In practice the holder is made in three parts which fold over each other, and each part carries one of three adjoining map sections. When travelling to the east or west of north, the pilot first uses the section showing his point of departure and proceeds as explained above until he arrives over some point on the extreme edge of that section. He then turns the holder over so as to bring the adjacent section into use. In order to assist him to find his position on the new section, the corresponding strips of each section are marked with the same number, so that he has merely to note the number of the strip he is leaving and pull the tabs of the new section until the strip bearing that number appears. The map of England and Wales most suitable for general use is the ordnance map to a scale of 4 miles to the inch. The part north of Manchester is divided into four sections and the remainder into eight sections, all the sections running north and south. The sections have a uniform width of about 10½ in., and each strip is 2 in. deep, so that, as four strips of a section are visible at once, the total area of country covered without moving the strips measures 42 miles by 32 miles. Pulling one of the tabs brings a fresh area of 42 miles by 16 miles into view, and, of course, covers up an equal area.



The Angus Compass Course Indicator for Aircraft; Constructed by Messrs. Edward Stanford, Limited, London.

As stated above, the sections are usually cut in the north-south direction, but if a pilot were flying regularly on an east-west course, or in any other particular direction, it would be more convenient to cut the map sections parallel to this direction, and this can quite easily be done. This method of mounting will also be appreciated by motorists, but for use in a car a twofold holder is recommended in place of the threefold pattern used in aviation.

24-H.P. SIX-CYLINDER SUNBEAM MOTOR CAR.

A place among the leading firms of motor-car builders has long been held by the Sunbeam Motor Car Company, Limited, of Moorfield Works, Wolverhampton. The company has a record of a long series of successes won both on the motor track and on the road, while during the war their products have made good in many branches of service. In bringing forward their 1920 models, which are respectively of 16 h.p. and 24 h.p., the Sunbeam Company have made no attempt to depart radically from the practice with which they have been so successful in the past, and the 24-h.p. chassis, which we illustrate on pages 683 and 686, will be seen to follow more or less standard lines. It is not in virtue of novelties of construction or arrangement, but rather as representative of the

24-H.P. SIX-CYLINDER MOTOR CAR CHASSIS.

CONSTRUCTED BY THE SUNBEAM MOTOR CAR COMPANY, LIMITED, ENGINEERS, WOLVERHAMPTON.

(*For Description, see opposite Page.*)

Fig. 1.

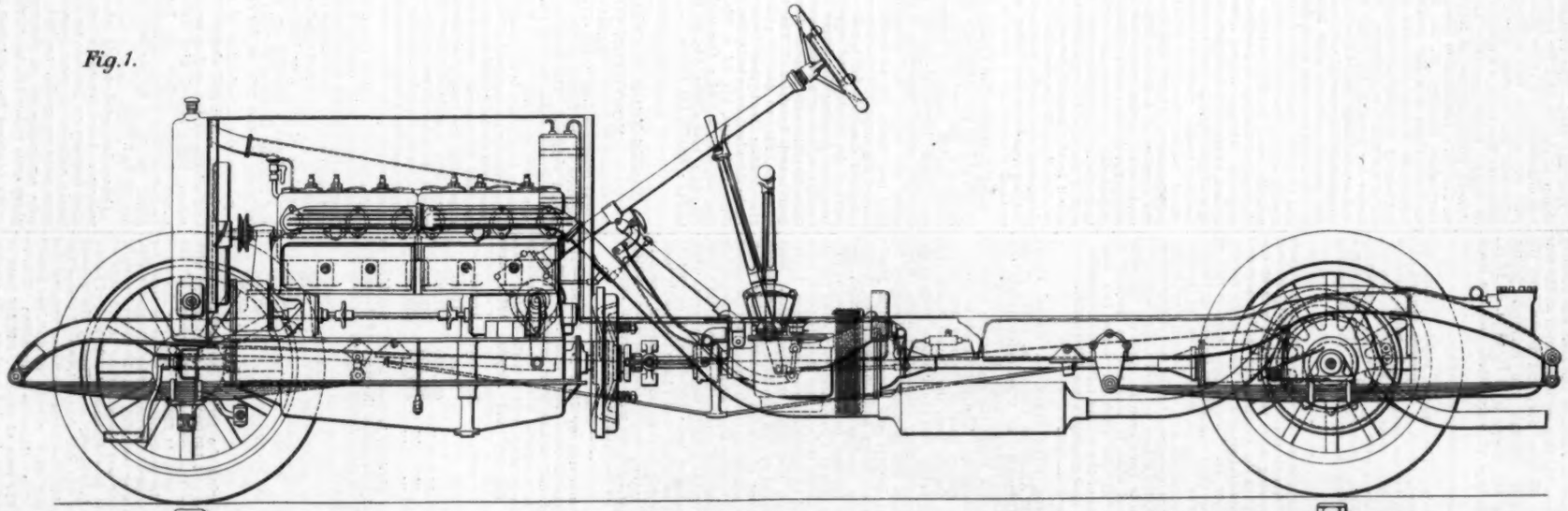
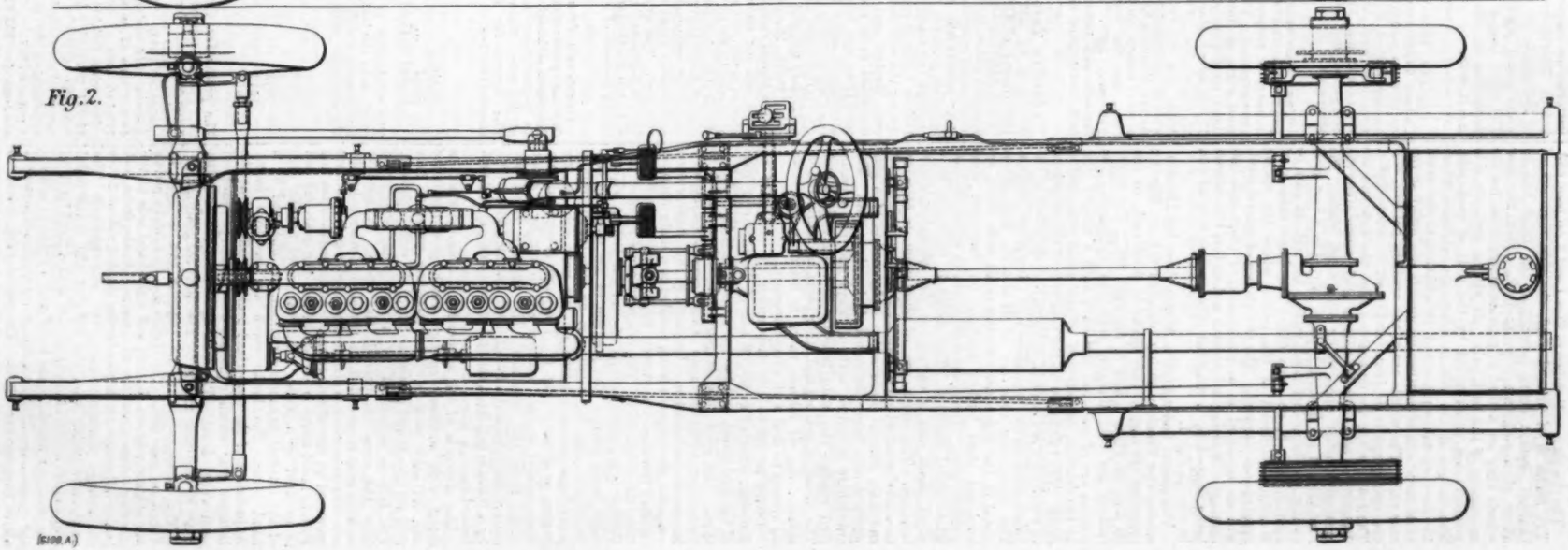


Fig. 2.



[S100.A.)

best type of practice and a sound engineering job, that the car is of interest.

The chassis is well shown in Figs. 1 and 2, on page 683. The frame is of pressed steel, the side members of channel section being inswept at the front end to allow of a sufficient steering lock. Over the rear wheels they are arched to provide ample room for the movement of the back axle. As will be seen, the side members are underbraced by the rods at each side. The flanges of the side members are widened where the inswoop takes place and, in addition to the usual cross-members, strengthening gussets are fitted at the rear end. The wheels are of the artillery pattern, and the springing, both front and rear, is semi-elliptic. The rear springs are underslung from the axle and are designed to be flat under normal load, which gives the greatest comfort when riding over rough roads. The rear axle, of the floating type, is carried in a cast-steel casing and is underbraced with a tie rod, as can be seen in Fig. 3, on page 686. The front axle is of H-section, stiffened at the points where the spring brackets are situated. The swivels are of special steel, and are mounted on a combination of plain and ball bearings. Steering is by worm and sector, the column being stayed by a diagonal tubular member, as can be seen in Fig. 1.

The engine has cylinders 80-mm. bore by 150-mm. stroke, the Treasury rating being 23·8 h.p. The six cylinders are cast in two blocks of three each, as can be seen in Figs. 4 and 5, on page 686. The water jackets are cast integral with the cylinders. The pistons are of cast-iron and have each a scraper ring at the bottom, in addition to the usual compression rings. The valves are on the near side of the cylinders, to which they are slightly inclined, and the whole of the valve mechanism is enclosed in dustproof casings. The connecting rods are of H-section, with white metal in the big ends. At the small ends there are hardened steel bushes working on hardened steel gudgeon pins. The crankshaft works in seven die-cast white metal bearings. The camshaft is driven by a silent chain and is carried on five phosphor-bronze bearings. The crank-case, of aluminium, is attached to a sub-frame, which is suspended at three points from the main frame. Lubrication is by means of a gear pump driven from the camshaft by skew gear. The crankshaft is drilled with oil ways and the pressure feed reaches the main bearings and big ends direct. The camshaft bearing and other parts are lubricated by splash. An oil release valve is fitted to the main oil system to deal with excess pressure.

Petrol is fed to the carburettor by means of an Autovac, situated at the off side of the engine in front of the dashboard, and the carburettor is of the "S.U." type. The inlet pipe is provided with a jacket in connection with the main water circulation system, to assist carburation. Ignition is by high-tension magneto, the magneto being coupled to a shaft mounted on ball bearings and driven by a silent chain direct from the crankshaft. The magneto coupling is of the Vernier type, which admits of very fine timing adjustment being made. The position of the magneto can be seen in Fig. 5. Cooling is by circulation from a centrifugal pump situated on the near side of the engine, as shown in Fig. 4. The pump is coupled to a shaft carried on ball bearings and driven by a silent chain from the camshaft. The radiator is of the honeycomb type and a fan of large diameter and driven by a Whittle belt from the end of the camshaft is placed behind it.

The clutch is of the leather-faced cone type and is fitted with auxiliary springs which give flexibility and an easy pick-up. The gear-box provides four forward speeds and reverse and is of the sliding pattern. The box is suspended by a three-point suspension from the cross-members of the frame. A positive locking gear is provided for the sliding wheels by the selecting gear which is operated through a gate quadrant mounted on the off-side frame. An internal-expanding Ferodo faced brake is carried behind the gear-box and is operated by a pedal. The rear wheel brakes, also of the internal expanding pattern, are operated by a hand lever. The brake shoes are cast-iron faced. Adjustment of the rear-wheel brakes is effected at the balance gear which equalises the brake pressure on each wheel drum. The final drive from the propeller shaft to the back axle is by helical bevel gearing.

The arrangement of the controls can be seen in Fig. 6, on page 686. The clutch and foot-brake pedals are respectively on the left and right-hand side of the steering column, and are adjustable. As the front seat is also adjustable, it is possible for the individual driver to arrange matters exactly to suit himself. The accelerator pedal is on the right of the brake pedal and can be worked in conjunction with a hand lever on the steering wheel. This lever and a lever to control the ignition are fitted to a stationary quadrant arranged above the steering wheel. The petrol tank, having a capacity of 15 gallons, is arranged between the rear ends of the side members of the frame, as shown in Figs. 1 and 2. The self-starter is attached to the crank-case on the ignition side of the engine and drives on to a spur ring mounted on the flywheel. The batteries are carried in a box on the near side running board. The electric lighting set is mounted at the rear of the engine on the near side, and driven from the water-pump spindle through two universal joints. The wheel base of the chassis is 11 ft. 4½ in. or 12 ft., depending on the type of body fitted, and the track is 4 ft. 6 in.

Chilean Mission.—The special mission from the Chilean Government, which is at present visiting this country, in return for the visit paid to South America by the British Mission under Sir Maurice de Bunsen, were last week the guests of Sir W. G. Armstrong, Whitworth and Co., Limited, and viewed the firm's Scotswood and Elswick works and the Armstrong shipyards.

The Reconstruction of the Belgian Iron Industry.—The reconstruction of the Belgian iron industry is progressing more rapidly than was at one time expected. Thus the Providence blast furnaces and steel works at Haumont started up the foundry department on September 14. The Angleur steel works at Tilleur were to start their second blast furnace by the end of September. The Thomas steel works, at present comprising two converters, and the Clabecq steel works, were to recommence operations by the end of September. At the Monceau Saint Fiacre works the steel works and several rolling mills have been in operation for some time, and the first blast furnace will be working by February, 1920. At the Cockerill works two blast furnaces and parts of the rolling mills are in operation, and the company now employs some 3,500 hands.

American Trade with Italy.—A special report submitted by the American Consul at Milan to the Department of Commerce at Washington points out that if Americans are to secure trade in Italy they must, amongst other things, lower the cost of the goods by eliminating intermediaries. The report reads as follows: "At present the greater part of the raw and manufactured products coming from the United States pass through too many hands, and the ultimate price to the Italian buyer is consequently exceedingly high. While during the war there was an almost utter disregard for cost, dealers and jobbers and manufacturing plants depended upon speculators and financiers for stocks, conditions are now tending to become normal, and attention is again focussed on prices. One reason why the United States played a comparatively small part in the Italian trade before the war was that its goods were invariably handled by intermediaries in London, Liverpool, Paris, Havre, Hamburg, or other cities. Most of the letters received at this Consulate from American firms ask for names of Italian concerns using given lines of goods, but seldom do the inquirers ask for names of parties likely to become their agent. Experience has shown that when names of prospective buyers have been furnished the result has usually been nil, whereas when American manufacturers have appointed a competent and reliable agent excellent results have frequently been obtained. The proper location for a general agent in Italy is Milan, as it is the industrial capital of the country, although particular interests may require an agent at Genoa because of its importance as a seaport."

Germany's Production of Iron and Steel.—The German production of steel and iron continues to fluctuate, although not to any great extent. There is an improvement as compared with the earlier months of the year, although August is a little behind July. The figures for January and August, 1919, were respectively:—

	January.	August.
	Tons.	Tons.
Pig-iron	501,000	567,000
Steel	554,000	740,000
Rolled sections	479,000	605,000

The production of pig-iron is now about one-third as much as in the last year before the war—1913—and the fluctuations which occurred during the war are shown in the appended table:—

	Tons.
1913	19,810,000
1914	14,890,000
1915	11,190,000
1916	13,280,000
1917	13,140,000
1918	11,750,000

The production during the period January–August of this year amounted to 4,140,000 tons, as compared with 7,460,000 tons for the corresponding period of the previous year and with 11,220,000 tons for the same period of 1913. The production of rolled sections for August, 1919, included 67,765 tons of half-finished goods, 48,912 tons of railway material, 34,478 tons of girders, 210,145 tons of bar and shaped iron, 46,523 tons of rolled wire, 106,544 tons of plates, 24,027 tons of tubes, 24,927 tons of rolling-stock, &c. During the present year the output of bar and shaped iron and plates has increased considerably, the increase in these commodities approaching 50 per cent. of the production during August, 1917. The Rhenish–Westphalian district accounts for 363,470 tons of pig-iron, 526,238 tons of steel, and 421,643 tons of rolled sections. As regards pig-iron, Siegerland and the Saar district come next with 54,965 tons and 56,223 tons respectively.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—The moulders' strike has caused a slump in the demand for foundry iron, but otherwise manufacturers, to a larger extent than for some weeks past, are entering into contracts to cover their commitments for finished goods. Forge iron is more abundant, but there is a marked shrinkage in the supply of basic. Prices generally are in favour of sellers. Current quotations are as follow:—Lincolnshire forge, 8*l.* 12*s.* 6*d.*; Lincolnshire basic, 8*l.* 7*s.* 6*d.* to 8*l.* 10*s.*; Derbyshire foundry, 9*l.* 2*s.* 6*d.*; Derbyshire basic, 8*l.* 15*s.* There is a fair contract business passing in hematites. Prices are unchanged. Engineering firms are largely occupied in supplying the requirements of motor construction concerns. British makers of motor lorries are pressing for larger tonnages of rolled steel, and several large orders are in hand for French manufacturers of commercial vehicles. Sheffield Corporation has placed contracts with local engineering concerns for the supply of five single-deck omnibus bodies at a cost of 2,625*l.*, petrol tanks to cost 720*l.*, and hot-water supply apparatus to cost 493*l.* The improvement in crucible steel is maintained. Furnaces closed down since the cessation of hostilities have this week been reopened. Output on an average occupies five days a week in place of three days a week up to a fortnight ago. Light castings are in tremendous demand for the building trade. Sheffield Corporation has nearly completed its first batch of 653 houses towards a total requirement of 15,000, and has just adopted plans for the erection of a further 700. Progress is also being made with works extensions recently suspended on account of building trade difficulties. The chief difficulty of tool and implement makers is to maintain deliveries up to the level of requirements. Railway delay is at the root of the trouble; manufacturers are largely helpless. A lull in the demand for engineers' tools is attributed to the effect of the moulders' strike. Output at file, pincer and wire works is maintained at a record level. Forging machines are being widely adopted by file makers.

South Yorkshire Coal Trade.—The improvement in the output at local pits is having a marked effect in vitalising business in the open market. Best steam hards find a ready market, mostly on contract account, for railways and home industrial users. Any surplus resulting from the partial suspension of shipping, goes to supplement the supply for household purposes. Cobbles, nuts and slacks are all scarce, contractors taking the bulk of the output. Collieries cannot keep pace with the increased demands for house coal. Consumers in all parts of the country, and especially in the Metropolitan area, are pressing for larger supplies. Furnace and foundry coke form a strong market at maximum prices. Gas coke is also very active. Nominal prices at the pit: Best branch handpicked, 33*s.* to 34*s.*; Barnsley best Silkstone, 33*s.* to 33*s.* 6*d.*; Derbyshire best brights, 31*s.* to 32*s.*; Derbyshire house coal, 28*s.* 6*d.* to 29*s.*; Derbyshire best large nuts, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire small nuts, 27*s.* 6*d.* to 28*s.* 6*d.*; Yorkshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; best slacks, 24*s.* to 25*s.*; nutty slacks, 23*s.* to 24*s.*; smalls, 19*s.* to 20*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—The announcement of the abolition of the licence system for export of pig-iron is indeed welcome. The termination of irksome control has long been wished for, but the action happens to have been taken at a time when it is of little consequence, as foundry iron, which is the quality in demand for abroad, is practically unpurchasable for foreign trade. Many merchants are fairly well bought on Continental account, but they do not easily obtain delivery with home needs so pressing and supply of foundry pig-iron still scarce. Forge iron is quite abundant, but this does not at all weaken the value of that quality. For home consumption, No. 1 Cleveland pig-iron is 164*s.* and No. 3 g.m.b., No. 4 foundry and No. 4 forge all stand at 160*s.*; whilst export prices are put at 5*s.* above these rates.

Hematite Iron.—East Coast hematite keeps in fairly good request, and traders hope for more extensive Continental business, notwithstanding financial obstacles to foreign trade. The Seaton Carew Iron Company is relighting a furnace, and blowing out one for repairs, so that three of their four furnaces will remain in blast. Nos. 1, 2 and 3 hematite are 200*s.* for home purposes and 205*s.* for shipment abroad; and No. 1 is 202*s.* 6*d.* for home use and 207*s.* 6*d.* for export.

Foreign Ore.—Indication of revival of transactions in foreign ore is still absent. Consumers continue to hold off the market as they are comfortably placed, and sellers, being behind with deliveries are not keen to secure further orders. So far this month imports against running contracts, however, are on quite a good scale. Rubio, of 50 per cent. quality, is round about 52*s.* 6*d.* c.i.f. Tees.

Coke.—Increased supply of coke would be indeed welcome. Local demand is very heavy, and deliveries to blast furnaces on Teesside are declared to be on a scale barely sufficient to meet essential needs. Fixed maximum rates are readily realised. Thus medium furnace coke commands 48*s.* at the ovens, and quality low in phosphorus makes 49*s.* 6*d.* at the ovens.

Manufactured Iron and Steel.—Great firmness characterises all branches of the finished iron and steel industries, and further advances would create no surprise. Manu-

facturers are overwhelmed with work and are compelled to refuse orders on account of being quite unable to give an undertaking as to delivery. To home customers, common iron bars are 22*l.*; marked bars, 25*l.*; strip iron, 23*l.*; steel ship, bridge and tank plates, 18*l.* 5*s.*; steel boiler plates, 21*l.* 10*s.*; steel angles, 17*l.* 15*s.*; steel joists, 17*l.* 10*s.*; steel strip, 22*l.*; steel hoops, 23*l.*; heavy sections of steel rails, 16*l.* 10*s.*; black sheets, 28*l.*; and galvanised sheets, 36*l.* Export prices are not fixed, these being matter for individual negotiation, but it is understood that they are slightly above home quotations.

North-Eastern Steelworks.—Some of the mills have been put into operation again this week at the North-Eastern steel works, where reconstruction is proceeding.

NOTES FROM THE NORTH

GLASGOW, Wednesday.

Scotch Steel Trade.—The Scotch steel works are this week getting under weigh once more, as the strike of bricklayers has ended and work has been resumed. It will be a little time before the different establishments are fully employed, but no time is being lost in getting plants restarted, and every endeavour will be made to overtake arrears. Already quite a number of those who were thrown idle have again started work, and as there are plenty of orders on hand the plate mills will be kept running at top speed for many months to come. The demand for plates is far and away ahead of the available supply, and in order to keep consumers going a large and steady output will be necessary. The meagre deliveries of late have occasioned the using up of reserve stocks and shipbuilders are pressing for supplies to enable them to continue working. Hematite, which was very scarce some time ago, is now very plentiful, and thus that commodity will not be the means of retarding operations. Sectional material is a shade quiet, but black sheets are the subject of much activity and a large tonnage is going through. Makers are regularly receiving urgent calls for deliveries, mostly of the heavier gauges, and so great is the demand at times that near date business can only be looked at in exceptional cases. Galvanised sheets are in good request and are called 35*l.* for 24-gauge. There are many inquiries in the market, for all kinds of steel material for shipment, but when home demands are met there is very little available for the export market. Prices all round are firm, and there seems little prospect of any easing off in the near future.

Malleable Iron Trade.—The conditions prevailing in the malleable iron trade of the West of Scotland during the past week or two have not altered, and makers continue very busy. There are plenty of orders on hand for bars for home requirements and very little foreign business is being transacted. The outlook on the whole is exceedingly satisfactory, and a good steady run is anticipated. Quotations continue firm and show no change, but the matter of delivery would almost seem to be a much more important item to the buyer than that of price.

Scotch Pig-Iron Trade.—The Scotch pig-iron trade which has been moving along on very steady lines of late, exhibits rather a brighter tone this week, owing to the restart of the steel industry. Stocks of hematite were accumulating, and some difficulty was experienced in getting rid of the output, but steel makers are now taking in satisfactory deliveries, and these will go rapidly into consumption. No. 1 foundry iron is still somewhat scarce, but the position of the other grades shows no change. The export side of the trade is still on a small scale, but with licences being granted more freely this branch of the industry is likely to open out steadily, as there are quite a number of good inquiries on the market. Prices are firm and without change.

Scotch Iron Moulders.—The Executive Council of the Associated Iron Moulders of Scotland, having considered the result of the ballot of the men, ordered the different branches to lodge strike notices to-day, and to intimate to the masters that a strike would commence on November 26 to enforce the demand for an advance of 15*s.* per week, with an equivalent advance on piece rates, which was refused by the employers a few weeks ago. It is intimated that one of the causes which influenced the men to vote for a strike was the fact that so many castings were being diverted here for completion from the strike areas in England, Ireland and Wales. Should the dispute in the latter countries not be settled by the 26th inst., the local ironmoulders will cease work partly in sympathy with their fellow-workers now on strike. The result of the ballot was: For a strike, 3,461; against, 2,368. Something like 8,000 men will be concerned in the strike, and of that number no less than about 3,000 are in the Glasgow area.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Coal Market.—The Executive Council of the South Wales Miners' Federation have had under consideration the question of the revision and the unification of the wages of various classes of colliery workers. The movement is so far in its initial stage, but the tentative scheme formulated indicates the demands for a substantial advance in the general wage rates. For colliers and a large number of other classes the basic figure is taken at 8*s.* per day, as compared with 6*s.* 10½*d.*, which is at present the highest figure, and applies only to coal hewers, timbermen and a few other piece workers. A special conference will be called before any steps are taken to open negotiations with the employers. For prompt business the coal market show little change. In isolated cases prices are a little stronger owing to individual collieries being more favourably situated in respect to supplies of tonnage and wagons. Generally, however, collieries are awkwardly placed because of a lack of empty wagons and with outputs increasing are obliged to grant concessions to buyers able to arrange quick shipment in order to secure an early release of wagons. Best and second quality Admiralty large coals range from 67*s.* 6*d.* to 72*s.* 6*d.*, and the leading Monmouthshire large from 65*s.* to 67*s.* 6*d.* Best steam smalls are round 52*s.* 6*d.*, with other grades in proportion. A good deal of business has lately been arranged for delivery over the whole of next year. One large undertaking had sold 250,000 tons of second-class Admiralty large coals to French buyers on the basis of 75*s.* f.o.b., and Italian buyers have contracted for a similar quantity of best Admiralty large at 70*s.* f.o.b. A French railway has also contracted for 25,000 tons of best small steams at just over 50*s.* f.o.b., while an important colliery company have sold practically the whole of its 1920 outputs of No. 2 Rhondda throughs at 57*s.* 6*d.* f.o.b. A number of contracts have also been arranged for patent fuel on the basis of 72*s.* 6*d.* to 73*s.* per ton f.o.b. delivery over the whole of next year.

The Iron and Steel Trades.—The settlement of the United States coal strike has eased the demand for tin plates. Makers generally are fully booked with orders over the next few months, and in most cases are unable to negotiate further business. Manufacturers are already in arrears with their deliveries, and only about 75 per cent. of the mills are working because of the lack of skilled labour. Current quotations are on the basis of 45*s.* to 46*s.* for the standard sizes.

CATALOGUES, &C., FOR CALIFORNIA.—The British Consul at Los Angeles, California, states that his office is inundated with trade papers and circulars from the United Kingdom, which are useless in that part of the United States. He points out that price lists should always be in dollars and cents, and in order to commence business with American houses, attractive circulars should be sent, giving the price (free of duty and carriage), in dollars and cents, for a small shipment. The average merchant in those parts will not take the trouble to find out what the carriage will be, and so will not give any orders, but if tempted with a lump sum to cover everything, he will probably give a trial order, out of which much business might subsequently develop.

NON-FERROUS MINING IN THE UNITED KINGDOM.—The committee appointed by the Board of Trade to consider the question of non-ferrous mining met on October 14, 15 and 16, under the chairmanship of Mr. H. B. Betterton, M.P., when evidence was given by Mr. C. A. Moreing, M.Inst.C.E. (of the firm of Bewick Moreing and Co.), general manager of the Tehidy Minerals, Limited, and East Pool and Agar, Limited, and representing the Cornish Chamber of Mines and the Joint Industrial Council of the Tin-mining Industry in the United Kingdom. Mr. Moreing stated that in his opinion, the mines on the Redruth and Camborne line of lodes should be amalgamated and worked on a large scale, a plan which held out the only hope of economic success in the future. He pointed out the real importance of the mining industry of Cornwall, not only to those actually employed in the mines and the population dependent on them, but also to the country at large. The committee is to hear further evidence from Cornwall.

INTERNATIONAL ATOMIC WEIGHTS.—Since 1906 the International Committee on Atomic Weights had not issued any report, possibly because the changes, they then proposed, were rather severely criticised, especially by Ph. A. Guye and E. Moles, of the University of Geneva. We have noticed some of their many papers on possible sources of error. The grounds of the criticisms were inconsistency in the proposed changes, that the International Congress of Applied Chemistry of 1912 had pronounced against any changes before the meeting of the next Congress, then planned for 1915, and that the war had made communication of the American, English and French members of the committee with the fourth German member impossible, and had seriously interfered with atomic weight research. Though these reasons have not lost their force, the three first-mentioned members, F. W. Clarke, T. E. Thorpe and G. Urbain, recently issued a new report for 1919–20, proposing several, not unimportant changes, and reviewing the work done since 1916. The changes are: Argon, A = 39·9 (against 39·88); boron, B = 10·9 (formerly 11); gallium, G = 70·1 (69·9); nitrogen, N = 14·008 (14·01); thorium, Th = 232·15 (232·4); yttrium, Yt = 89·33 (88·7). The proposed argon change rests on the work of A. Leduc. Smith and Van Haagen have worked on boron at the Carnegie Institution, Washington; they have also found that the atomic weight of fluorine (19) should probably be raised, but that is not yet proposed; their memoir does not appear to be available over here so far. The change in gallium is made on the strength of the researches of Richards, Craig and Sameshina; thorium has been further studied by Hönig Schmid, and yttrium by Hopkins, Balke and Kremers. As regards nitrogen there is no new work, but the figure 14·008 represents the average of the best determinations known. Important work has also been done on hydrogen (H = 1·008), carbon (12), bromine (79·92), lead (Pb = 207·20), uranium (U = 238·2), helium (He = 4), &c., but no changes are so far suggested for these elements. Considering the objections mentioned and the fact that most of the new atomic weights rest on the investigations of one worker (or group of workers) only—men of distinction, of course—the alterations seem premature.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, November 21, at 6 p.m., at the Institution, Storey's Gate, St. James's Park, S.W. "The Present Position of Mechanical Road Traction," by Mr. C. G. Conradi, of Derby, Member.

THE STAFFORDSHIRE IRON AND STEEL INSTITUTE.—Saturday, November 22, at the Education Offices, St. James'-road, Dudley, when a paper on "Future Developments on Puddled Iron Manufacture" will be read by Mr. J. E. Fletcher (past president). Chair to be taken at 6.30 p.m.

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, November 25, at 5.30 p.m., at the House of the Royal Society of Arts (John-street, Adelphi). An address will be delivered by the president on "The Work of Lambert." The hon. secretary will present a Report on Progress, and reference will be made to the work of the various committees appointed. New developments in photometry and high candle-power lamps, &c., will be shown.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 25, at 5.30 p.m., extra meeting, when a lecture will be given on "Some Aspects of Metropolitan Road and Rail Transit," by Mr. Henry Herman Gordon, B.A., Assoc.M.Inst.C.E.

ROYAL SOCIETY OF ARTS.—Wednesday, November 26, A paper on "British Trade in China" will be read by Mr. H. B. Morse, LL.D., late Statistical Secretary, Chinese Imperial Maritime Customs. The chair will be taken at 4.30 p.m. by Mr. Byron Brenan, C.M.G., late H.B.M. Consul-General, Shanghai.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, November 27, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. "Carbon Arcs for Searchlights," by Messrs. C. C. Paterson, O.B.E., J. W. T. Walsh, A. K. Taylor and W. Barnett.

FEDERATION OF BRITISH INDUSTRIES.—The following appointments were made at the annual meeting of the Federation of British Industries on Wednesday, the 12th inst., Sir Vincent Caillard relinquishing his position as president on the termination of his year of office:—President: Mr. Peter Rylands (Messrs. Rylands Brothers, Limited, Warrington); vice-presidents: Mr. Godfrey Isaacs (Marconi Wireless Telegraph Company, Limited), Mr. Philip Lockhart (Messrs. W. and A. Bates, Limited, Leicester), Sir William Pearce, M.P. (Association of British Chemical Manufacturers). In addition, the seven retiring vice-presidents were re-elected.

"SURPLUS."—The issue No. 12 of *Surplus*, dated the 15th inst., the publication of the Disposal Board, Ministry of Munitions, is now on sale at the price of 3*d.* It contains information and sketches concerning the utilisation of boxes, of which the Government has a large assortment. The sketches shown do not exhaust the possibilities of the utilisation of the boxes, and many articles could be made with them, such as shelves, cupboards, summer-houses, tool-sheds, garden frames, work benches, plate racks, &c. A catalogue giving full particulars of the different types of boxes and the depots at which they are lying can be obtained from the Controller, Miscellaneous Stores Section, Caxton House, Tothill-street, London, S.W. Application for the boxes required should then be made direct to the nearest depot.

SURFACE TENSION OF OILS.—A new method of determining the surface tension of oils was recently described by K. Grunmacher and W. Bein in vol. lx of the Scientific Transactions of the Imperial Standardising Commission, Berlin. Two glass plates are vertically mounted on a base; by means of screws they can be moved so as to form a wedge of a small adjustable angle. The oil is fed into the space between the two plates and rises by capillary attraction, the liquid boundary taking the shape of an equilateral hyperbola. In order to facilitate measurements a series of confocal hyperbolæ is photographed on one of the glass plates. To hasten the settling of the oil, which may take a long time, the plates are moved to and fro' by means of a micrometer screw. The surface tension values thus obtained for various oils—turpentine, olive, resin, castor, hemp oil, &c., and also benzine—agree with the values determined by Wilhelmy's meniscus method.

PERSONAL.—The directors of Turner Brothers Asbestos Company, Limited, Rochdale; the Washington Chemical Company, Limited, Washington Station, County Durham; and Newall's Insulation Company, Limited, Newcastle-on-Tyne, announce that it is their intention to submit proposals to the shareholders with a view to the amalgamation of the three companies. The amalgamation is to be of such a character as will permit each hitherto separate company, to retain its name and to maintain its present policy. Each of the companies, after amalgamation, will continue to be separately operated by its present directors and *personnel*. The directors expect that increased efficiency will result from this proposed change.—The Warsaw Company for Trade and Navigation, Limited, announce from their head office at Warsaw that they have opened branch offices in London at Holland House, 1 to 4, Bury-street, E.C. 3, and in Liverpool at 20, Chapel-street, and that they have appointed as their manager for the United Kingdom Mr. Robert T. Chapman, who will have entire charge.

24-H.P. SIX-CYLINDER MOTOR CAR CHASSIS.

CONSTRUCTED BY THE SUNBEAM MOTOR CAR COMPANY, LIMITED, ENGINEERS, WOLVERHAMPTON.

(*For Description, see Page* 682.)

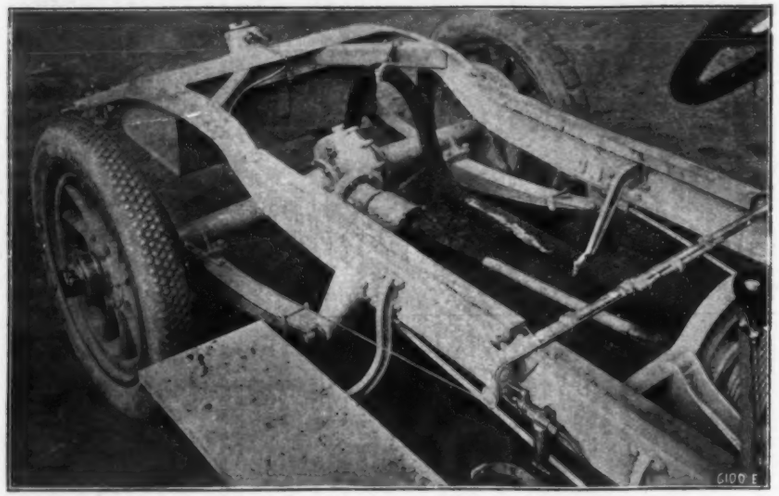


FIG. 3. VIEW SHOWING REAR END OF FRAME AND BACK AXLE.

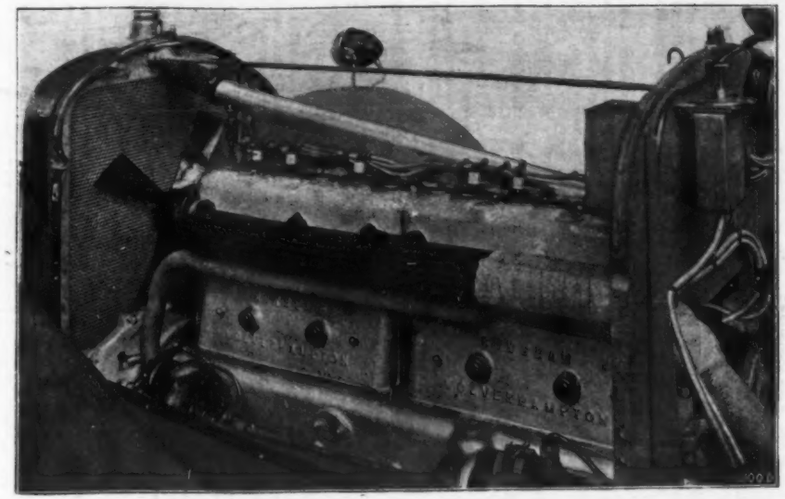


FIG. 4. EXHAUST SIDE OF ENGINE.

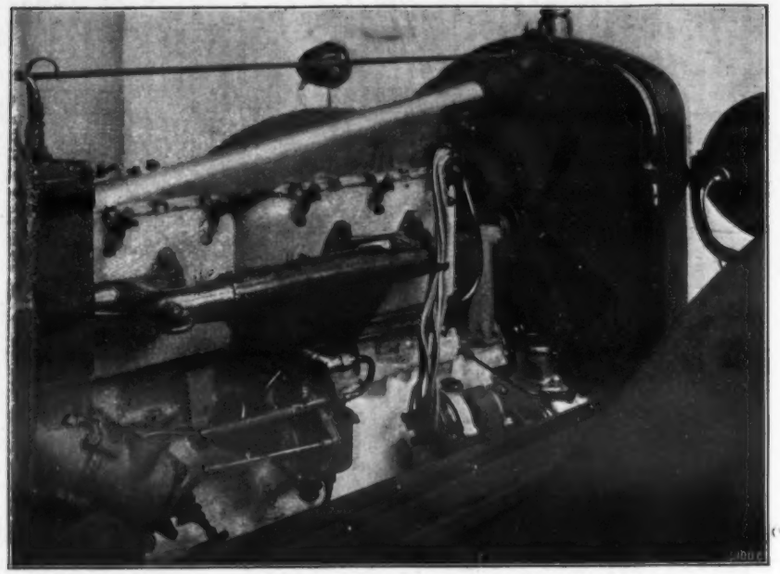


FIG. 5. INLET SIDE OF ENGINE.

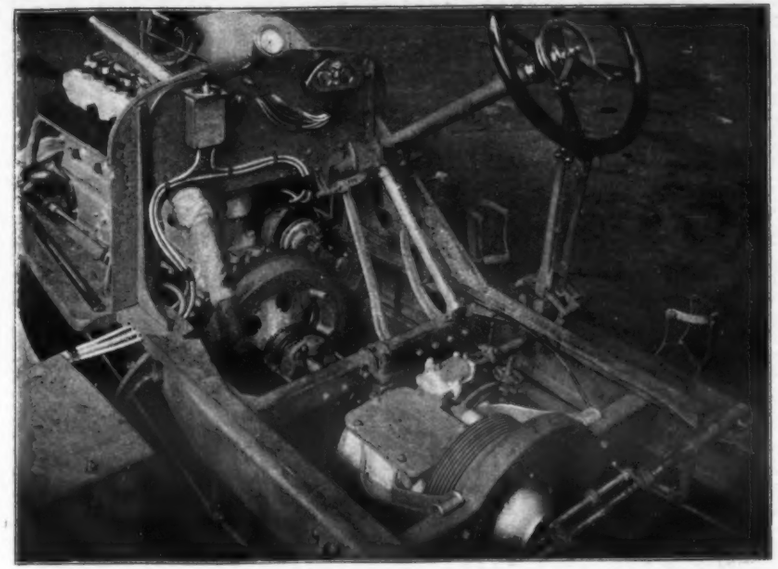


FIG. 6. VIEW SHOWING GEAR-BOX AND CONTROLS.

HELL GATE BRIDGE, NEW YORK; APPROACH VIADUCT.

MR. GUSTAV LINDENTHAL, CHIEF ENGINEER.

(For Description, see Page 674.)

Fig. 77.

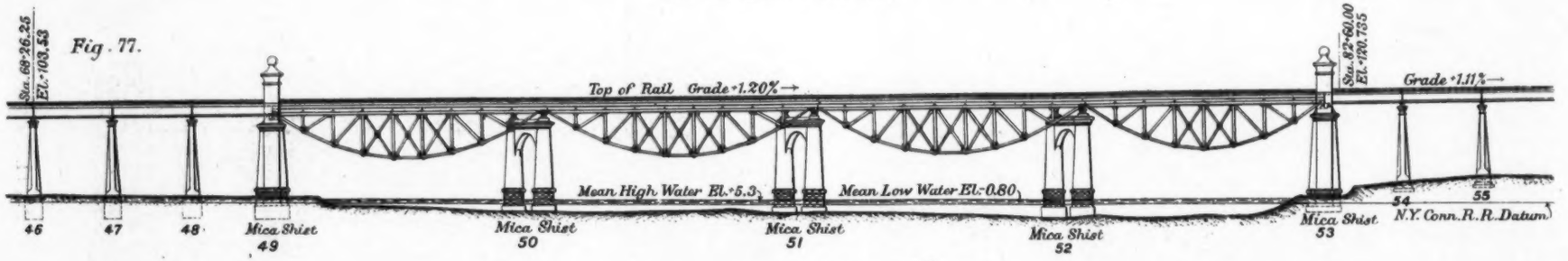
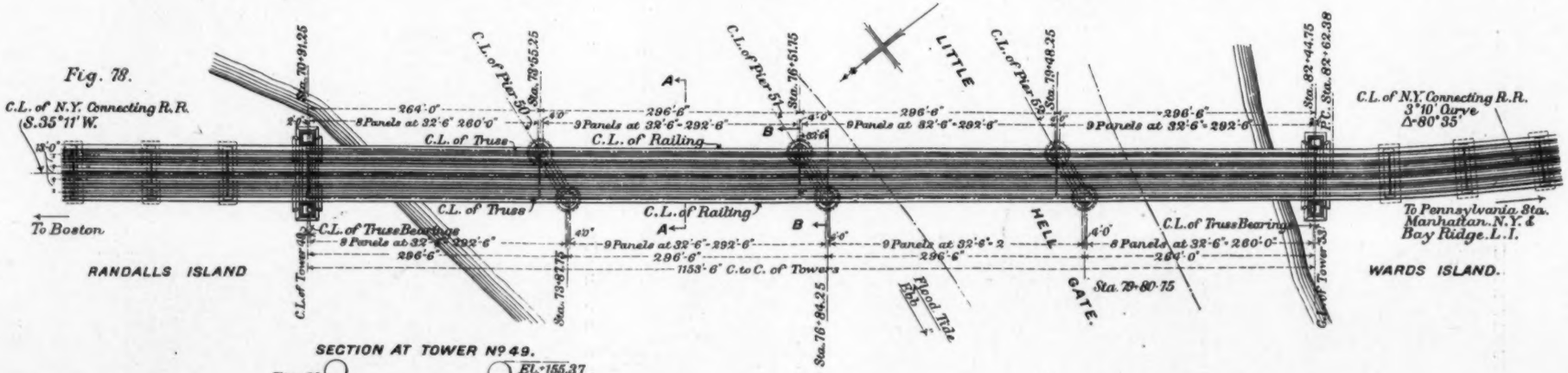


Fig. 78.



SECTION AT TOWER Nº 49.

Fig. 79.

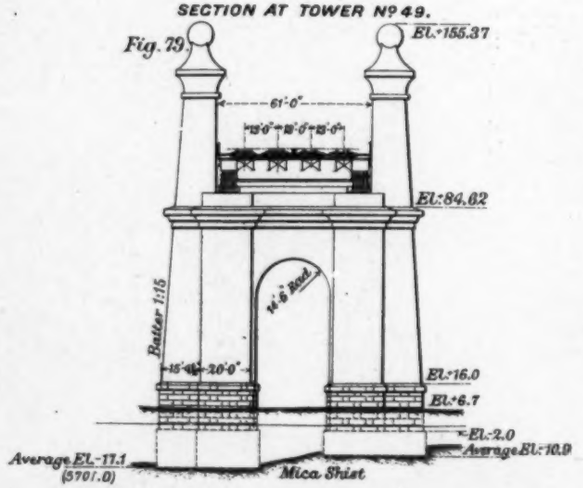


Fig. 80. SECTION A.A.

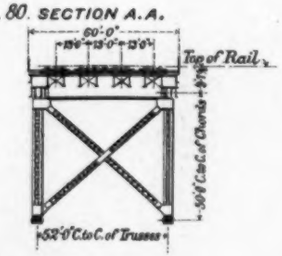
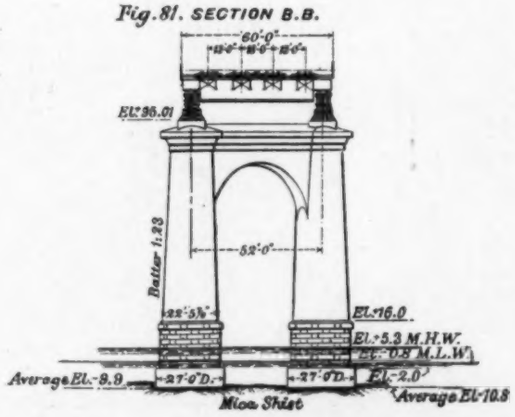


Fig. 81. SECTION B.B.



FIGS. 77 TO 81. LITTLE HELL GATE BRIDGE.

HELL GATE BRIDGE, NEW YORK.

MR. GUSTAV LINDENTHAL, CHIEF ENGINEER.

(*For Description, see Page* 674.)

Fig. 82. Little Hell Gate Bridge in Course of Construction.

Fig. 83.

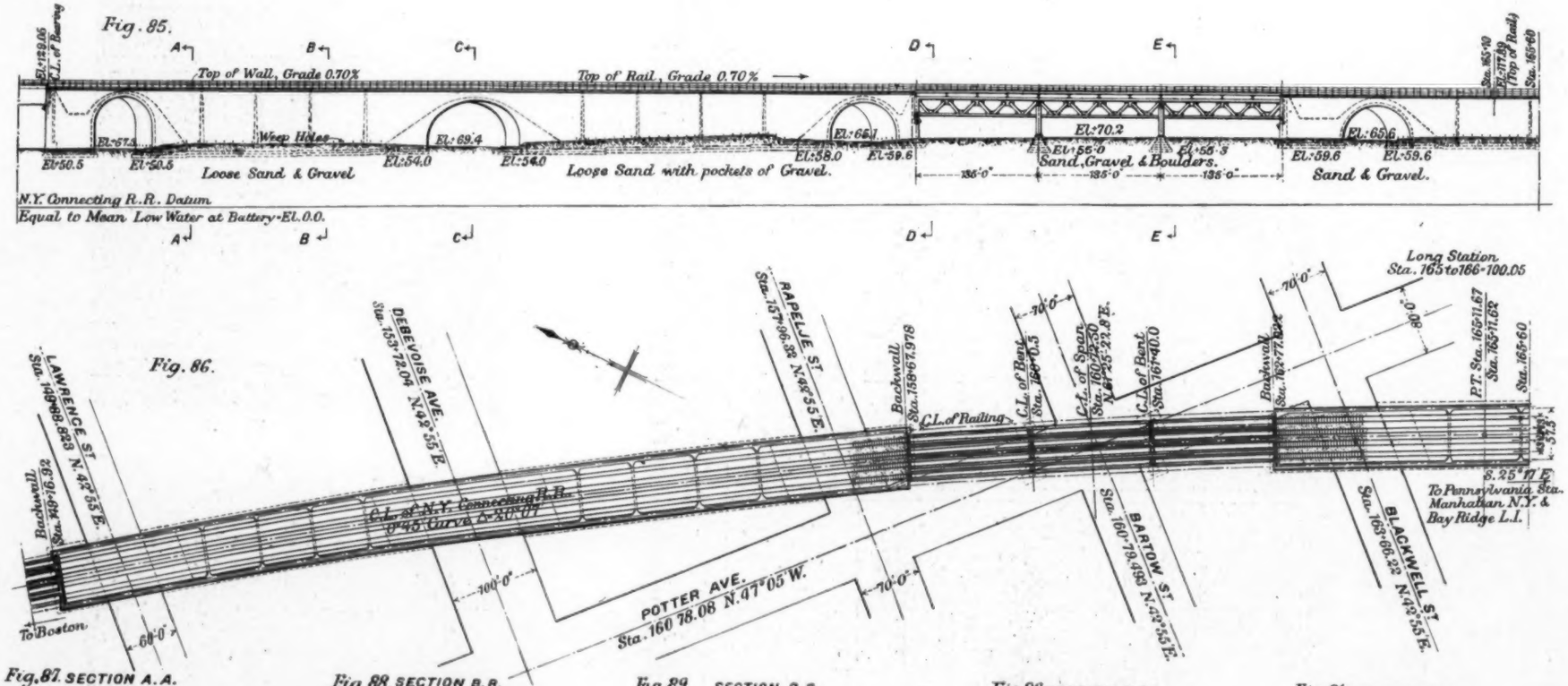
Fig. 84.

Figs. 83 and 84. The Erection of the Steelwork of Little Hell Gate Bridge.

HELL GATE BRIDGE, NEW YORK; APPROACH VIADUCT.

MR. GUSTAV LINDENTHAL, CHIEF ENGINEER.

(For Description, see Page 674.)



FIGS. 85 TO 91. EASTERN VIADUCT, LONG ISLAND.

HELL GATE BRIDGE, NEW YORK.

MR. GUSTAV LINDENTHAL, CHIEF ENGINEER.

(*For Description, see Page* 674.)

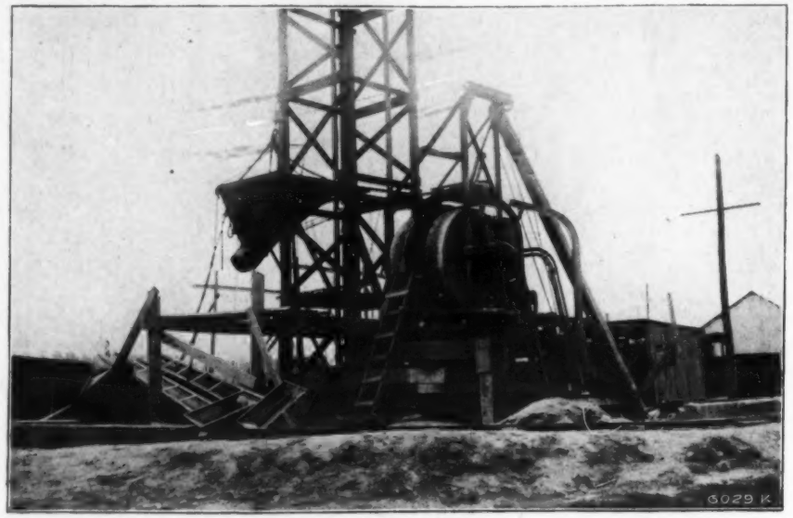


FIG. 92. STANDARD TYPE OF CONCRETE MIXER.

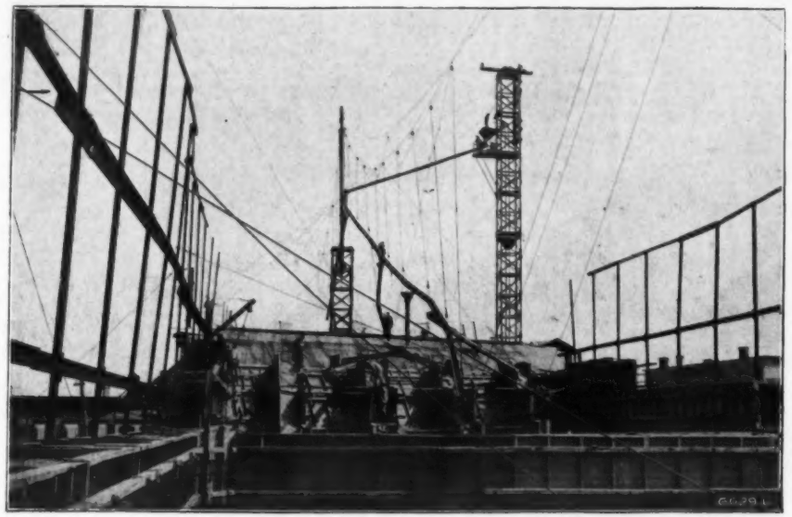


FIG. 93. CONVEYING CONCRETE TO THE ARCH SPANS OF VIADUCT.

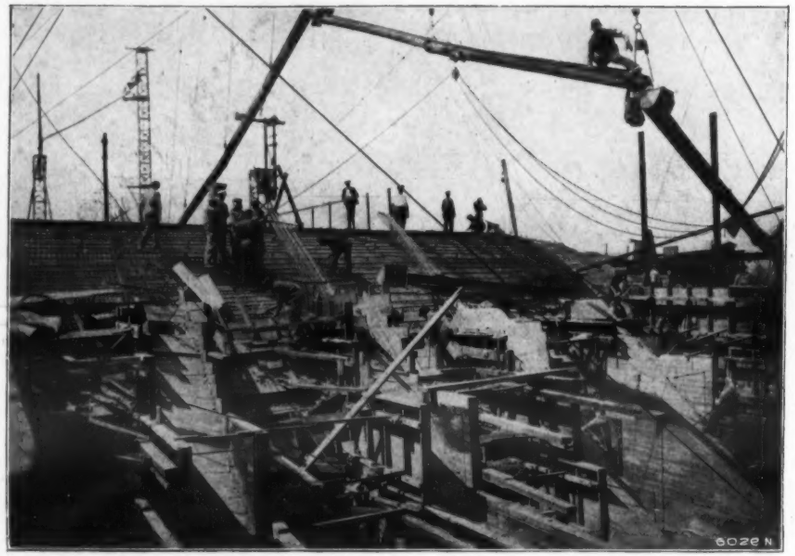


FIG. 94. REINFORCEMENT FOR ARCH SPANS OF LONG ISLAND VIADUCT.

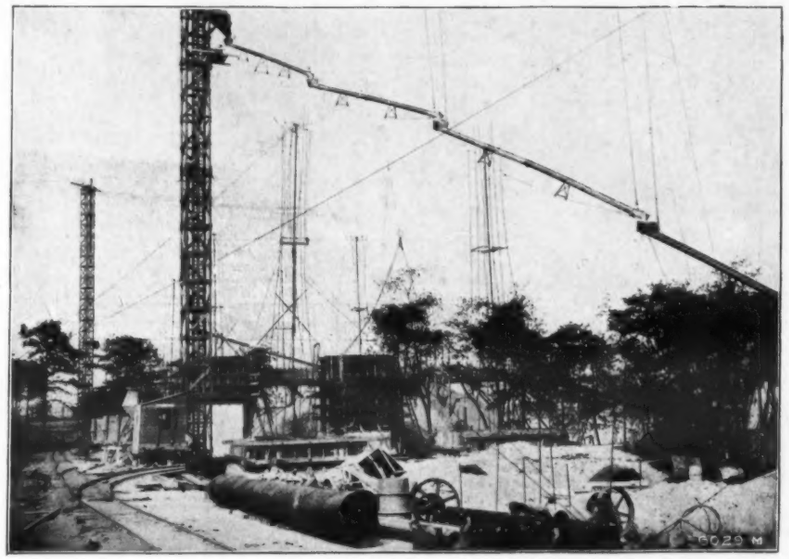


FIG. 95. FORMING CONCRETE PIERS FOR RANDALL'S ISLAND VIADUCT.

(*To face page* 677.)

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TELEPHONE NUMBERS—3883 and 8596 GERRARD.

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NOTICE.

Owing to the enormous increases in the cost of paper, engravings, and printing charges generally, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 9d. to 1s. per copy. This increase will date from and include the issue of Friday, January 2, 1920. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 685.

ENGINEERING.

FRIDAY, NOVEMBER 21, 1919.

INDUSTRIAL TRIBUNALS.

PERHAPS the most important clause in the Bill now before Parliament for the establishment of Industrial Courts, is that providing for the institution of a Court of Inquiry to establish the actual facts of the case when a trade dispute either exists or is apprehended. The compelling effect of public opinion has been repeatedly exemplified in the past; notably so in the great strike of the dockers some thirty years ago. So soon as the public realised the wretched status of casual labour at the docks, the success of the strikers was assured. The pressure of public opinion had again much to do with the ending of the recent railway strike. The data published by the Government showed most conclusively that the men had little or no warrant for their action, and not all the ingenuous special pleading of the men's representatives was able to weaken the conviction of the public, that the lightning strike was justified neither by the present conditions of railway labour nor by its future prospects. Of course, on both sides of a trade dispute there are extremists. On the one hand, there are those who resent the public interfering with a man's right "to do what he likes with his own," and on the other, men who object on principle to any accommodation between capital and labour, and to any growth of mutual good feeling between the two instruments by the aid of which our great creators of wealth, have so remarkably bettered the amenities of life.

In the very nature of things, however, the extremist is an exception, and the average man in the main demands merely a square deal, and will yield to the pressure of public opinion if he can be assured that this is based on the actual facts of the case, and not merely on plausible *ex parte* statements. It is therefore of first importance that machinery should be devised by which, in the case of differences between capital and labour, the community should be in a position to ascertain the actual facts about the question in debate. Indeed, we may go further and insist on the importance of this machinery for bringing home these facts to the rank and file of the very workmen concerned. These are not always accurately stated by their representatives, as was notably exemplified in the municipal strike at Leeds in 1913, where the reports made to the men by their representatives in the negotiations were so false to the facts that the Corporation Committee had to insist that all further proposals should be submitted in writing. Further, in the recent railway strike, conversation with some of the men concerned showed that they were under the impression that an attempt was to be made to reduce their wages to the level of 1914. How this belief arose it is difficult to understand, but possibly certain flowers of rhetoric reared by speakers at local meetings were mistaken for sober statements as to the true import of the Government's offer.

Recognising the important part which may be played by well-informed public opinion in the settlement of labour troubles, the Canadian Government passed some little time back an Industrial Disputes Investigation Act, in the belief that this would afford a more satisfactory solution of the trades disputes than the system of compulsory arbitration which has been established in the sister Dominion of New Zealand. The same view has been taken by the committee on Relations between Employer and Employed in their report* just issued. This report has probably had much to do with the decision to include in the Bill the clause which we have discussed above.

Moreover, the necessity for impartial investigations of this kind has been very clearly shown in connection with the existing coal crisis. The estimates of the weekly takings of the men put forward by the miners' representatives and by the colliery owners differ most materially. On the one hand, the pitman is represented as pursuing an arduous and dangerous occupation for a pittance that verges on the limits of possible subsistence; whilst, according to other estimates, he is in receipt of an income that might be envied by many a professional man. Such a court of enquiry as it is proposed in the new Bill to institute would make it possible to cross-examine those responsible for these conflicting figures, and to determine which, if either, fairly represents the average conditions in the industry.

Whilst such courts of inquiry will undoubtedly serve a useful end, much more is required if a *modus vivendi* is to be established between capital and labour. In his able and interesting address delivered last week to the Federation of British Industries, Sir Vincent Caillard referred to the extraordinary suspicion with which labour too frequently regards those who create and find employment for the implements of industry. To no little extent he admitted some employers have themselves been to blame. The suspicion has been in part created by organised propaganda, and there has been no corresponding organisation to discount the effect produced by these *ex parte* statements.

It has unfortunately not been the practice to associate the men with the management even in matters of mutual concern. It is only within recent years, for example, that works safety committees have been appointed, in which elected representatives of the men concert with the management in mitigating the dangers inherent in so many industrial undertakings. Those who have served on such committees and learn how much thought the management expends in pursuit of safety, will not easily fall a victim to the belief in the theoretical capitalist of the Fabian Society, actuated solely by motives of cupidity. How many of those who have seen the nationalisation of the mines advocated on the grounds that the safety of employees would thereby be promoted, realise that in such matters the State has always lagged behind the private employer? Every important safety device has, in fact, been due to private enterprise, and has only been enforced by legal enactment after having come into pretty general use as the result of voluntary action.

There are other industrial matters besides questions of safety in which assistance may well be sought from the men. In most manufacturing industries there are no doubt bounds to the degree of partnership possible. The attempt to develop a new industry, to tap new sources of wealth, or practicalise a patent specification, involves the assumption of gambling risks. Lord Masham, for example, is said to have expended 200,000*l.* before he solved the problem of utilising silk waste. Workmen cannot fairly be asked to share either the risk or the responsibility for such ventures, all essential as these are to our progress, and, consequently, the more enterprising firms may have greater difficulties in securing the co-operation of labour than those content to lead a more humdrum existence, copying and adapting ideas in place of originating them. Nevertheless, even the most progressive firm would benefit by letting their workmen know more of their aims and achievements. There is, moreover, the

* *Report on Conciliation and Arbitration.* His Majesty's Stationery Office. (Cd. 9099.) [Price 1d.]

danger that if the abilities of the abler men are not utilised for the benefit of the industry, they may be perverted to its detriment. This has undoubtedly happened frequently in the past, where output has been of set purpose restricted, in circumstances requiring considerable ingenuity to achieve this anti-social end.

Some progress has undoubtedly been made. Sir Vincent Caillard is able to state that the National Alliance of Employers and Employed has already justified its existence. There are now 30 local committees which are actively engaged in the work of conciliation, and have been called in on several occasions to prevent and settle strikes. He is also a convinced adherent of the policy advocated in the report of the special committee on the control of industry, which, whilst noting the impossibility of the workmen controlling questions of industrial policy, does recognise their claim to have an effective voice in settling the general conditions governing the industry in which they are engaged. Works committees, for example, might well have a say in the fixing of equitable piece rates. The average Englishman can generally be depended upon to return a just verdict if an appeal can be made to his sense of fair play. No doubt, in establishing such a system certain bad traditions will have to be lived down. The workman who remembers how, in the past, the "office" quietly appropriated the result of any special effort or intelligence for which he was responsible, by cutting down his rate, may no doubt at the outset be a somewhat prejudiced arbitrator; but with a new spirit actuating the management, reciprocity on the part of the workman is probably only a matter of time.

THE NEW THEORIES OF RELATIVITY.

Some twenty years ago or more, when Sir J. J. Thomson demonstrated the existence of the electron, many sensational statements appeared, to the effect that the atomic theory of matter had completely broken down and that whole departments of physics would require recasting from their very foundations. Indeed, even before this event the "Energetic" school of philosophers had advocated the abandonment of the famous hypotheses of Dalton and Avogadro, on the ground that they could do without the atom or the molecule. In discussing the new theories of relativity, a short while back, Professor Jeans made an exactly similar statement with regard to the luminiferous ether, with which, he said, the relativists could dispense. It is somewhat singular that the atomic theory and the hypothesis of a luminiferous ether have each been in vogue for about a century before being seriously challenged. The atomic theory has triumphantly survived the attack on it, being now more firmly held than ever, and if the alternative to the luminiferous ether is to be the hypothesis of a fourth dimension of space, it is to be hoped that the attack on it will ultimately prove equally abortive. The object of a scientific theory is to describe the abstruse in terms of the more familiar, and the prospect of abolishing an ether, however peculiar and embarassing its properties may prove to be, in favour of the extremely abstract and artificial idea that physical phenomena are merely concomitants of curvature in a space of more than three dimensions, is far from inviting.

There are, at any rate, some substantial *a priori* reasons for hope that it may prove possible to frame some new view of the ether and of matter which will account for certain outstanding anomalies as accurately as Professor Einstein's hypothesis has been proved to do.

For example, an unlimited straight line in ordinary Euclidean space may be regarded as built up of an infinite number of points. A plane can be generated by moving this line at right angles to itself, and in this case each point in the original line will trace a new straight line, each of which consists also of an infinite number of points, so that the total number of points in a plane is (infinity)^2. It is easy to see that the number of straight lines which can be drawn in a plane is also equal to ∞^2, so that the number of points in a plane is equal to the number of lines in it; and for each point we can accordingly assign or enumerate a corresponding straight line. It follows from this that for every geometrical proposition about points in a plane there is a corresponding proposition about lines. A familiar instance is afforded by Pascal's mystic hexagon and its converse. Pascal showed that if a hexagon were inscribed in a conic, and its opposite sides produced to meet, the three points of intersection thus obtained would lie in a straight line; or, in other words, the "junctions" of opposite lines would meet in a straight line. Conversely we have the theorem that if six tangents be drawn to a conic, and the opposite points of intersection be joined by straight lines, these three lines (being the "junctions" of opposite points) meet in one and the same point.

If we pass from two to three dimensions of space the number of points in this space is equal to ∞^3, but the number of straight lines which can be drawn in this space is ∞^4; that is to say, it is equal to number of points in a hypothetical space of four dimensions. Hence, just as before, for every theorem about points in four-dimensional space there must be a corresponding theorem about lines in three-dimensional space, and as the latter can be visualised it will for most people be preferable to treat a problem about such lines as a three-dimensional one, rather than to adopt the mathematically acceptable alternative of discussing it as a problem concerning points in a hypothetical space of four dimensions.

This illustration points at least to the possibility that phenomena which are described by the new relativists in terms of four-dimensional space may ultimately be found quite capable of being successfully dealt with in the three-dimensional space with which we are all familiar, though most of us, no doubt, might find a difficulty in defining it adequately.

The history of the question is of interest. It is now nearly 200 years since Bradley observed and explained the phenomenon of aberration. He found, in short, that the apparent position of a star in the heavens varied with the direction in which the earth happened at the time to be moving. On the corpuscular theory of light at that time in vogue, the explanation was very simple. As an analogy, if rain be falling vertically, and a pedestrian is in motion, the rain will appear to him to be falling not vertically but to be approaching him from the direction in which he is walking, having thus an apparent horizontal component equal to his own velocity of motion. Substituting the corpuscles of light for the rain drop, and the motion of the earth for that of the pedestrian, we get the phenomenon of aberration. The direction in which a star appears to lie, in fact, only coincides with its true direction under somewhat special conditions. When the undulatory theory of light was adopted aberration could be explained in the same fashion as before on the assumption that the ether was at rest. So long as the old corpuscular theory held the field it was obvious that there was no possibility of determining the absolute velocity of the earth in space. All we could tell was its relative velocity with respect to other stars or systems, and this form of the doctrine of relativity is at least as old as Newton. If, however, the ether were stationary as seemed to be the case from the phenomenon of aberration, a new prospect opened out and there appeared to be the possibility at any rate of finding out what was the velocity of the earth relatively to this assumed stationary ether.

Take, for instance, a tube of length l and place it parallel to the ecliptic. At some period of the day this tube will be a tangent to the orbit of the earth, and will thus have an endlong motion in space of some 18½ miles per second. Suppose light be passed down this tube and reflected back again.

If v be the velocity of light and s that of the earth in its orbit, the velocity of the light relatively to the tube, when passing down it, will be $v - s$, whilst on its return after reflection it will be $v + s$. Hence the time taken to go down the tube will be $\frac{l}{v-s}$, and that taken to come back will be $\frac{l}{v+s}$. Hence the total time will be $\frac{l}{v}\left(\frac{1}{1-\frac{s}{v}} + \frac{1}{1+\frac{s}{v}}\right)$.

Now $\frac{1}{1-\frac{s}{v}} = 1 + \frac{s}{v} + \frac{s^2}{v^2}$ + &c., and $\frac{1}{1+\frac{s}{v}} = 1 - \frac{s}{v} + \frac{s^2}{v^2}$ + &c.

Moreover, $\frac{s}{v}$ is a very small quantity, so that neglecting terms of higher order, the time taken by the light to go down the tube and back again will be $\frac{l}{v}\left(2 + \frac{2\,s^2}{v^2}\right)$. That is to say, the time will be same as if the tube had no endlong motion and had a length equal to $l\left(1 + \frac{s^2}{v^2}\right)$.

If six hours later a second observation be made the tube will now be normal instead of tangential to the motion of the earth in its orbit, and will thus have no endlong motion due to this. At first sight it would seem that under these conditions the time required to pass up and down it would be simply $\frac{2\,l}{v}$. This, however, is not quite correct, because during the time the light takes to pass down the tube and back again the observer will have been carried on by the motion of the earth to a new position. Hence the light in passing up and down the tube describes two sides of a triangle. Its path is thus lengthened and is equal to $2l\left(1 + \frac{s^2}{v^2}\right)$. Thus to the order of approximation adopted the time taken in the first case will be greater than in the second in the ratio of $1 + \frac{s^2}{2\,v^2}$ to 1. It will be seen, therefore, that if these times could be measured we ought to have the means of determining s, the rate at which the earth is moving relatively to the ether. When, however, an experiment based on this conception was made, it was found that the time taken for the light to traverse the tube was identically the same whether the tube was pointed along or, perpendicularly to the earth's path through space. The natural conclusion to be drawn was that the ether was dragged along by the earth, but this was inconsistent with the phenomenon of aberration, and also with other experimental results, which all indicated, as Young said about 100 years ago that, the ether streamed through matter "like the wind through a grove of trees."

An explanation of this anomaly was found in the electrical theory of matter which, as shown by Fitzgerald and Lorentz, involved as one result that when a rod moved endlong through the ether it was shortened, and this shortening was such as to cancel out exactly the term $\left(1 + \frac{s^2}{2\,v^2}\right)$ which appears in the expression for the ratio of the virtual lengths of the tube, as given above. There was, it was further shown, no possible way of detecting this change of length directly. Any apparatus used as a measure underwent the same change.

During the last century mathematicians have interested themselves in discussing the properties of a space in which the three angles of a triangle are no longer equal to two right angles. As illustrating the properties of such a space, Helmholtz has instanced the reflection of real space in a spherical mirror. Every point and every object in the real space outside the mirror has its reflection therein, but if two equal rods are reflected the lengths of the reflections will not in general be equal.

Thus the length of the reflection of a 2-ft. rule will depend upon the direction in which it is pointed. If this direction be changed, the length of the reflection will be changed; yet, nevertheless, the dimensions of the reflection of any object measured by the reflection of the rule will be the same as the dimensions of the real object as measured by the real rule. We have obviously something here analogous to what has been found to happen in real space, in which, as appears from Michelson's experiment and the Fitzgerald-Lorentz explanation thereof, the real length of our measuring rods depends upon the direction in which they are pointed. If this direction be tangential to that in which the earth is moving the real length is shorter than if the rod be directed at right angles to this. It was presumably considerations of the kind set forth by Helmholtz that led to the attempt to seek an explanation of Michelson's results by

assuming that our space is not really Euclidean, and that if we could only measure large enough triangles we should find the sum of the three angles to differ from two right angles.

The hypothesis that physical phenomena are really due to curvature in space of four dimensions is, of course, not new. Clifford discussed it over fifty years ago; but the important point is that Einstein has succeeded in deducing from such an hypothesis certain numerical results, which can be put to the direct test of observation and experiment.

The first of these results has reference to an anomaly in the motion of Mercury. The planets, as is known, revolve in ellipses round the sun, but the major axis of each of these ellipses has itself a certain angular velocity and is thus changing its direction in space. In the case of Mercury the rate of this change of direction was greater by 42 seconds a century than could be accounted for by the known forces in operation. This anomaly, it is stated, is fully accounted for by Einstein's theory. It may be observed in passing that Mercury is not the only celestial object which fails to keep time. Shortly before his death, Simon Newcomb said that certain fluctuations in the motion of the moon were entirely unaccounted for by theory and that these constituted the most enigmatical phenomenon presented by the celestial motions. It will be interesting if it turns out that an explanation of these can also be afforded by the new theory.

Another deduction from this theory was that the deflection of a ray of light passing near the Sun should be twice as much as could be accounted for by the ordinary theory. Until quite recently it was not believed that light was in any way affected by gravitation. Many years ago, however, Maxwell showed from theoretical considerations that light must exert a pressure on any body on which it fell. In other words, that light must have momentum. This conclusion has been experimentally verified, and the question then arose as to whether light had also weight. In this latter case a ray passing near the Sun should be deflected. In our next issue we propose to print an article by Sir G. Greenhill, showing how this deflection can be calculated. Actually it turns out from the observations taken during the recent eclipse of the Sun that the actual deflection is twice as great as can thus be accounted for and is in accord therefore with the figure derived by Einstein from his theory.

Another somewhat startling statement made by the relativists has been in regard to the nature of time. It is, however, easy, even without introducing a fourth dimension of space, to see that two observers using one and the same "clock" might have quite different scales of time. Let us assume, for example, that the "clock" is the Sun, and that the time of its rotation on its axis is the fundamental unit adopted. Suppose this to be measured by the times of reappearance of a sun spot. Then if the observer is, say, on a comet approaching the Sun, he will have got nearer the Sun during the period of rotation, and the light that tells him that the sun spot has reappeared will not have so far to travel as before. On the other hand, if another observer is on a comet going away from the Sun, the reverse will be the case, so that though both observers are using the same "clock" they will have hours of different lengths, although fixed by exactly the same recurrent phenomenon.

The anomalies in time to which relativists refer may imply more than this; but to those of us who are not pure mathematicians, no simple and clear explanation of the matter has yet been furnished. The best, so far, is perhaps that given by Professor Eddington in the lecture reported in our issue of February 8, 1918. Briefly put, it is assumed that time may be taken as a fourth dimension of space. Now in ordinary plane co-ordinate geometry, if the axes of co-ordinates are turned through an angle the new co-ordinates of a point may be considered as compounded of the old. The new y, for example, is equal to $a\,y^1 + b\,x^1$, where y^1 and x^1 denote the old co-ordinates.

That is to say, the new y contains as a component part of the old x. Or if y denotes length and x breadth, the new length will comprise in it some of the old breadth. Applying this to the hypothetical four-dimensional space in which the co-ordinates are length, breadth, height and time, then if the axes of reference are tilted the new time will contain some of the old height, some of the old breadth and some of the old length. If our space be really curved or warped the directions of the axes of co-ordinates will change as assumed, and thus the time co-ordinate in, say, Arcturus which is moving towards us at the rate of 200 miles a second, will not be the same as it is on the earth.

Owing to our inability to visualise a fourth dimension of space, such a concept as the foregoing is far from satisfying to the engineer, and it is to be devoutly hoped that some other method of co-ordinating the hitherto recalcitrant phenomena will be found less revolutionary in character and more capable of representation as a piece of mechanism. Mere mathematical solutions or representations of physical phenomena are seldom satisfactory to the mind. Most of us, like Clerk-Maxwell, want "to see how the thing works."

AN ELECTRICAL PROVING HOUSE.

The value of the work which has been carried out by the British Engineering Standards Association is beyond question, but, and in this undoubtedly lies one aspect of their value, the specifications of the association have no authority other than the goodwill which the name of their promulgators carries. In spite of this voluntary aspect of these specifications, they have won very general acceptance not only at home but to a considerable extent abroad. In a way they have become a hall-mark of British material and performance. In his presidential address, of which we reproduce the major part on another page, Mr. Roger T. Smith, speaking before the Institution of Electrical Engineers, on the 13th inst., and referring to the electrical specifications of the British Engineering Standards Association, raised the question of an electrical proving house. Such an institution, by examining and marking electrical material, would certify that it complied with the standards which have been set by the association.

This is a matter which has been discussed by the Institution of Electrical Engineers in the past, but its importance is such that one welcomes the publicity which the president's address gives it. The matter has yet hardly reached the stage of concrete proposals, but Mr. Roger Smith quoted an extract from the proposals and decisions of the Government which were issued by the Prime Minister on August 22 last. The extract was as follows: "There is growing recognition of the importance for the future of British industry of the principle and practice of standardisation, but so far the State has done little. It is proposed to set up at the Board of Trade a Department of Standards: (1) To promote and co-ordinate standardisation generally, and (2) to establish and administer such testing institutions as may be found necessary, and authorise and, so far as may be required, supervise the testing work carried out by technical institutions, trade organisations, or private concerns."

This quotation from an official document would appear to suggest that testing laboratories, other than those they already have, are to be set up by the Board of Trade. Without questioning the good faith of the pronouncement, however, it is necessary to remember that Government proposals do not always end in performances. In the present instance we should like to think that no hasty official steps are to be taken to "supervise the testing work carried out by technical institutions, trade organisations or private concerns." It can hardly be questioned that the British Engineering Standards Association would not have been the success it has been had it taken the form of a department of the Board of Trade, or of any other civil service organisation. A proving house under such auspices might, however, be satisfactory enough, if it was prepared to work in terms of the standards already fixed by the Association, and not to attempt to overhaul the whole matter again from the first in the light of its own limitations. Proving or disproving in terms of fixed standards and by fixed methods, is work well suited to a civil service organisation and sympathetic with its methods.

It will be noted in the quotation from the Prime Minister's pronunciamento which we have given, that nothing is said of a proving house and that testing institutions are referred to in a general way. If, however, anything is to be done towards this Government control of testing no better start could be made than in the direction of a proving house such as that suggested by Mr. Roger Smith, and we welcome the new prominence he has given to the matter. The general control of testing by the Government is a matter into which we cannot enter now, but supervision by the Board of Trade of testing carried out by trade organisations and private concerns, presumably for their own purposes, is a matter on which a good deal may be said. We should imagine that the ultimate result of such supervision would be that there would be nothing to supervise.

We have referred specially to this section of Mr. Roger Smith's address, as it appears to us to deal with a subject of much importance. The main feature of his speech, however, was his analysis of some aspects of the financial side of main line railway electrification. As we reproduce this very valuable part of his address in full elsewhere, it is not necessary to refer to it further here. Mr. Smith also touched on questions of education and labour in an illuminating way and some of his views on these matters we may have occasion to refer to later.

CIVIL AVIATION.

Since the official commencement of civil flying on May 1 last, the Department of Civil Aviation has apparently accomplished some really useful pioneer work, which, although not likely to attract much public attention at the moment, will certainly be recognised in the future if civil aviation develops as we think it must. The department has endeavoured to assist British firms to establish regular services between London and Paris, London and Brussels, and London and Amsterdam, and some such services are already in operation. One of the most useful features of the work, however, has been the reconnaissance and development of Imperial air routes. We learn from the synopsis of a report on the work of the department, by Major-General Sir F. H. Sykes, recently issued by the Air Ministry, and covering the period from May 1 to October 31 last, that the Cairo-Karachi route has already been opened for military purposes and will soon be available for civil traffic. A chain of landing places has also been established on the route from Cairo to the Cape, and it will probably be possible to fly over the whole of this route, on an experimental basis, before the end of the year. The air navigation regulations may need some slight modifications as a result of experience gained with their application, but no serious difficulties have occurred.

Some very interesting, and highly satisfactory, data relating to accidents, supplied by certain firms engaged in civil air traffic, are included in the report. From this, we gather that, in the period under review, 21,000 flights have been made and 52,000 passengers carried. The total number of flying hours amounts to 4,000, and the total mileage covered to 303,000. No passenger has been killed in civil flying, although 10 have been injured, as also have 6 pilots; but 2 pilots have unfortunately been killed. The total number of accidents which have occurred is 13, or 1 in 1,615 flights, a figure which will probably be considerably improved on in the course of time. Only 1 passenger in each 5,200 carried has been injured, or 1 in each 30,300 miles flown, but in this connection it should be noted that accidents are most likely to occur when starting-up or landing, and as the average flight has been of short duration (just over 14 miles) the risk of accident has been greater per mile flown than would be the case with ordinary commercial journeys. Experts from the Department are sent to investigate and report on all accidents, and this will doubtless tend to reduce their number.

Good work has also been done in connection with the inspection and licensing of aerodromes, the licensing of pilots and ground engineers, the inspection and registration of machines, methods of signalling and communication in the air and on

the ground, aerial navigation, and other matters. Among the latter meteorological work must be included as a matter of vital importance to the development of commercial aviation. It is a noteworthy fact that, although the claims of other departments upon the meteorological organisation of the Government are fully realised, arrangements have been made for the transfer of the Meteorological Office to the Civil Aviation Department. Weather maps are being produced at 6-hour intervals, and reports and forecasts covering various aerial routes have been issued, together with maps showing the speed and direction of the wind at high altitudes over each.

In considering the whole question of civil aviation it must be remembered, as we have pointed out on other occasions, that its development is a matter of national importance, not only for its commercial value, which must not be underrated, but more especially on account of its influence in a crisis such as that through which we have just passed. The uses of aviation in warfare have been rendered so obvious of late that its effect in future wars can easily be imagined. It is therefore of the first importance to keep the aviation industry in being, and to maintain an organisation from which a supply of machines and trained men might be drawn in times of stress to supplement the *personnel* and *matériel* of the Royal Air Force. Civil aviation, if sufficiently well developed, would form such a reserve, and also assist commerce, but it is doubtful whether the financial reward of the pioneers will be sufficient to encourage rapid development. Much depends upon the growth of a steady demand for rapid transport, and, at the present moment, this seems more likely to arise in connection with the carriage of mails than of passengers or merchandise. According to Major-General Sykes' report, the Postmaster-General is doubtful whether the demand for express mails between the more distant towns of the United Kingdom is sufficient to justify the running of services for mails only, and this view is probably correct, but on the Continental and Imperial routes, where the time-saving would be very considerable, the inauguration of regular aerial mail services appears to be a much more attractive proposition. Contracts for the carriage of mails would certainly assist the development of civil aviation. If we assume that the industry cannot at first be entirely self-supporting, some State assistance will be necessary, since its national importance can hardly be questioned. Three ways in which Government aid may be granted are referred to in Major-General Sykes' report. The Government might set aside a certain sum as a direct subsidy, as has been done in France, or make a grant to approved aerial transport companies proportional to the mileage flown and weight carried; or the assistance might take an indirect form, such as the provision of aerodromes, the collection and distribution of meteorological data and other information, and also the provision of means of communication. Our own view is that civil aviation will eventually be able to support itself without help, but we are in agreement with Major-General Sykes in thinking that a combination of the second and third methods of State assistance mentioned above, is desirable to help the industry over the present transition period.

NOTES.

The Road Board.

From the ninth annual report of the Road Board just issued it appears that the applications for advances during the past 12 months amounted to 218,831*l*. Practically the whole of the applications had reference to the improvement of road crusts. As is well known, the income of the Board is now derived almost entirely from the interest on its investments, the motor spirit duties and motor carriage licenses having since 1916 being paid into the general revenue of the country instead of being ear-marked for road improvements, as was the case before the war. Owing to this, the total receipts of the Board last year were but 194,906*l*., or less than one-fourth of the total in 1916. Last December, however, the demobilisation committee of the War Cabinet decided that a special grant of 8,000,000*l*. should be provided for promoting road improvements during this year, the administration being entrusted to the Road Board, and it is hoped that it will thus be possible to reconstruct nearly 200 bridges which are now inadequate to traffic requirements. The report includes a very full discussion of a number of proposals for new roads in the London Docks area. Here the congestion of the highways is becoming increasingly serious with the growth of the trade of the port. This congestion is increased by the relatively small proportion of motor traffic, since horsed transport is slower and occupies a greater area of roadway relatively to the total load carried. A census taken in April, 1918, of the traffic passing over Canning Town Iron Bridge showed that in 17 minutes 88 horse-drawn goods vehicles were counted and only 20 motor vans, lorries or tractors. The passenger traffic in the same period comprised 22 bicycles, 1 motor car, 16 motor omnibuses and 14 electric tramcars. A noteworthy feature of the traffic in this district is that it is practically all local traffic. The Road Board consider, however, that the present condition of affairs is little likely to continue with the further development of motor traction, and that new roads in this area should be laid out on the assumption that horsed vehicles will tend to disappear, and that the average length of haul may be substantially increased.

The Channel Tunnel.

On Wednesday, the 12th inst., a deputation of members of the Channel Tunnel Committee of the House of Commons waited on the Prime Minister, at 10, Downing Street, to urge that the consent of Government be given to the construction of the tunnel. The deputation was introduced by Sir Arthur Fell, chairman of the Channel Tunnel Committee. In the course of his remarks to the deputation, the Prime Minister referred to the facilities which a tunnel would have given this country during the war. There was no doubt, he added, that early in the war the Germans could have seized both Calais and Boulogne if they had made a dash for these places; they did not think it worth while, which was one of their cardinal blunders. Certainly they would have done so had there been a Channel Tunnel. On the other hand, the Allies' tactics would have been directed to suit the requirements. What the Government had decided upon was this, Mr. Lloyd George further stated: It would like to examine the scheme a little more carefully; it, also, would like the military and naval advisers to examine a little more definitely what were the dangers of a surprise attack. It was undesirable to give away our isolation and the protection of the 25 miles of water that separated us from the Continent. The Government simply proposed that the problem should again be gone into very carefully from the military point of view, and the naval and air point of view, and it would then be in a position to give a definite answer. The fact that this country was an island had been the means of saving the liberty of Europe many a time. He did not want it to cease being an island, and he wanted to be quite sure, before he committed himself, that Government action would not deprive this country of its providential advantage in that respect. Apart from that—if we were reassured under that head—there was everything to be said for the Channel Tunnel. Politically there were no objections to it. It struck the imagination; it opened the road right through to the East, and facilitated intercourse with our next door neighbour, with whom we had linked our fortunes. Further, scientific developments might make the sea even much more perilous in war-time than it had been, and the tunnel might be a guarantee against such developments. Those were the points which the Government wished to consider more fully.

Parliament, Science and Reconstruction.

It is a commonplace that the success of a technical society is dependent in a preponderant degree on the personality of its secretary. Under the guidance of Sir Henry Trueman Wood the Society of Arts has a most admirable record, and the Council has now fittingly recognised the services of its past secretary by appointing him as its chairman for the ensuing year. In his address at the opening of the new session, delivered on Wednesday last, Sir Henry sketched the industrial history of the nation since the foundation of the society in 1756. This was practically contemporaneous with the outbreak of the seven years' war, which was terminated by the victorious peace of 1763. The cost of this war laid a heavy burden on the country, but our resources had not, of course, been strained to anything like the same extent as they were by the Revolutionary and Napoleonic wars of 100 years ago. Then, as now, Sir Henry observed, England had rescued Europe from the arrogant domination of an unscrupulous autocrat and then, as now, she was wellnigh exhausted by her efforts. Yet in a few years she was stronger, richer and more prosperous than ever before. It is to be hoped that in this instance history may repeat itself. Sir Henry pointed out that steam power played a large part in promoting our recovery. In this matter we were then ahead of all other nations, but it must be confessed that there is little prospect of our enjoying a similar advantage in the immediate future. Of course, as Sir Henry points out, Parliament is in some respects more appreciative of the value of science as applied to industry than it was 100 years ago, and has at length agreed to subsidise on a fairly liberal scale industrial and scientific research. When it comes, however, to the practical applications of such research the politicians of to-day are, we fear, just as obstructive, though perhaps from different motives, as their forefathers of a century ago. Then, Sir Henry observed, the chief function of the State towards invention was to apply the brake to the wheels of progress. A patentee who offered his invention to the Government was snubbed, and every hindrance possible put in the way of the practical application of his ideas. We run, now, Sir Henry considers, to the other extreme; but for our own part we are inclined to think that this view is hardly borne out by experience. The history of the "tanks" as recorded during the recent inquiry shows that some of our Departments at any rate have not forgotten the art of snubbing and suppressing the sanguine inventor, and, moreover, every proposal to develop cheap power in this country by the only methods offering a reasonable prospect of success meets invariably with the most embittered opposition in Parliament. The prognosis for our rapid recovery from the strain of the war is therefore, we fear, less hopeful than it might be, and we must look to improvements in our educational methods to popularise more enlightened views on questions relating to industry and economics.

Fuels for Motor Vehicles.

In the course of his most interesting presidential address to the Institution of Engineers and Shipbuilders in Scotland, dealing mainly with the application of the internal-combustion engine to the problem of mechanical transport, Dr. T. Blackwood Murray gave some valuable data relating to the use of alcohol, and other fuels, in motor vehicles. In some experiments carried out by the French War Office in 1910, a mixture of 50 per cent. alcohol, 35 per cent. benzol and 15 per cent. petrol, was tried in comparison with pure benzol and pure petrol, and from the results given it appears that 46·3 gross ton-miles were obtained per gallon of alcohol mixture, while for petrol and benzol the corresponding figures were 53·2 and 57·1 respectively. Dr. Murray used the prices for the fuels in bulk without including Government taxes, and, with these assumptions, taking alcohol at 1*s*. 3*d*., benzol at 1*s*. 10*d*., and petrol at 1*s*. 11½*d*. per gallon, the cost per ton-mile works out at 0·45*d*. for petrol, 0·412*d*. for alcohol mixture, and 0·385*d*. for benzol. It is perhaps fairer, for purposes of comparison, to take the prices quoted above rather than those actually current at the present time, since the duty on industrial alcohol renders its price of 10*s*. per gallon practically prohibitive for use as a motor fuel. Dr. Murray is confident, however, that denatured alcohol could be delivered to the consumer at the price stated above, and, if we take the current prices of petrol and benzol as 3*s*. 0½*d*. and 2*s*. 9*d*. per gallon, respectively, the cost per ton-mile would be 0·53*d*. for alcohol mixture, 0·578*d*. for benzol and 0·686*d*. for petrol. Dr. Murray also gave some interesting data as to the cost of power production in internal-combustion

engines using alcohol, petrol and paraffin. He takes the calorific values of these fuels as 11,000 British thermal units, 19,000 British thermal units, and 20,000 British thermal units per pound, respectively, and the brake thermal efficiencies of the engines using them as 30 per cent., 23 per cent. and 20 per cent., respectively. The fuel consumptions in gallons per brake horse-power hour he gives as 0·093 for alcohol, 0·075 for petrol, and 0·079 for paraffin, and with these consumptions the costs per brake horse-power hour work out at 1·40*d.*, 1·76*d.* and 1·42*d.*, respectively. For the purpose of this calculation the price of paraffin has been taken as 1*s.* 6*d.* per gallon, and those of alcohol and petrol as 1*s.* 3*d.* and 1*s.* 11½*d.* per gallon, respectively. The great attraction of alcohol as a motor fuel is, of course, the fact that the supply of raw materials from which it is manufactured, being of vegetable origin, is practically inexhaustible. The prospect of producing it in large quantities in this country, Dr. Murray does not regard as very encouraging, but the materials from which it can be manufactured are so varied and widespread that our whole supply of motor fuel could certainly be produced within the British Empire. Doubtless the approaching exhaustion of petroleum supplies, and the present high price of coal and its by-products, will lead to still further consideration of the use of alcohol as a motor fuel.

THE MINING ENGINEER'S RESPONSIBILITY FOR COAL OUTPUT.

In his presidential address to the Warwickshire and Staffordshire Branch of the Association of Mining Electrical Engineers, and read at the meeting in Birmingham on the 14th inst., Mr. E. P. Hollis dealt in a highly practical way with the development of principles of efficiency in factories generally and in mining particularly. We make a few excerpts :—

Our real problem is, given full freedom, How can the engineer augment production from the mines ? The only way to increase production is to put the planning of the production scheme entirely in the hands of the skilled mining engineer. Owners can do their best to increase production, they can pour money like water into the scheme, but unless that scheme matures under the influence of the engineer, it is in all probability doomed to failure.

Let us think what the members of this association do in the course of their daily work. They control the entire power plant of the mine, they tend the power-house, the winder, haulages and coal cutters, each of which are instruments of production. Now when you go into a factory you know that you may have two sections of a works each equipped with the same amount of machinery, one producing more than the other. Why ? Because in the well-organised factory we have what is termed a production officer, a man who plans out the way the work is passed through the shops, who allocates jobs to the various machines, who, seeing that if one section of the machine shop is acting as a "bottle-neck," immediately procures additional machinery for that section, and who, in general, sees that the fullest utility is made of every detail of the plant. He times the operators and sees that they work efficiently without undue fatigue, and he procures for them every instrument for maximum production.

In mining work the increase of production has never been considered properly in this way. You will find in a mine all sorts of "bottle-necks" which as practical men you will have met from time to time. There have been mines in which the winding plant was inadequate to deal with the heaviest output that could be procured if every section of the mine were working to its maximum. There have been mines in which the haulages have been inadequate to handle all the coal that could be produced.

You remember that during the last session I initiated a discussion upon the merits and demerits of electrically-driven coal cutters, and I was greatly surprised by the general concensus of opinion in their favour. As an electrical engineer I have known that the coal cutter was one of the most difficult pieces of machinery to design and run, but it was very clear from the remarks you made on that occasion that the electrically-driven coal cutter had won its spurs and was a most potent factor for increasing production. In fact, it is now realised that the electrically-driven coal cutter is the only method of getting maximum production contingent, of course, upon the circumstances being favourable for its use. What you have to guard against very strongly is the introduction of a few of these machines in a casual way, for you will know that this is no proper way of testing their effect upon production. Maximum production can only be obtained by machine mining on an intensive scale, and that does not mean merely putting a few coal cutters into a mine. It means very much more than that. You have to begin by saying, "We are going to get a maximum output from our mine. How are we going to get it ?" You have to lay out your mining scheme with the application of a maximum number of machines. You have to see that the method of working is adapted to the machines. You have to provide not merely an adequate, but an over-adequate haulage system, so that there are never times at which this system is overstrained and congestion occurs at any part of the working. You have to see that the winding plant is large enough to handle the output expeditiously. You have to see that the various ways and roads about the mine are never congested. You have to see that the best winding system and the best haulage system available are installed. You have to lay down properly equipped repair shops for all kinds of plant, lay in sufficient spares, and standardise the plant throughout. More particularly you have to make sure that adequate protection against breakdown is provided so that it is never possible for a section of the mine to be shut down through a breakdown of the plant serving it. The care with which the plant in the mine is attended has also a bearing upon production. If through inefficient or inadequate care the plant breaks down the whole working of the mine may be disorganised, the scheme put out of gear and, in consequence, there is a big delay in output, which cannot be made up for a considerable period. That will be avoided if the authorities put in properly-skilled attendants.

There is without a doubt no industry into which the same degree of skill in electrical engineering is put as in the mining industry. From my own knowledge, I am quite certain that the mining electrical engineer is not sufficiently consulted, and therefore does not apply himself as closely as he might to the problems of production. If some incentive were given, if it were known to the mining electrical engineer that his experience is valued, and if it be appreciated that he can give most valuable advice, and that his experience fits him for grappling with the problems involved in increasing production, then he will be given incentive to apply his knowledge to increasing production.

A Second Colonial "Local Section" of the Junior Institution of Engineers.—The Council of the Junior Institution of Engineers has received a petition from Assam, signed by a number of engineers engaged for the most part in the tea industry, but also in railway and other public services, to sanction the formation of a local section of the Institution in that district. At an inaugural meeting held at Tinsukia, on Monday, September 8, Mr. E. F. Heron, M.I.C.E., executive engineer, Lakhimpur Division, was elected chairman ; Mr. E. L. Greenhough, agent and general manager, Assam Railway and Trading Company, was elected vice-chairman ; Mr. J. F. Brebner, engineer and acting manager, B.I. Tea Company, Limited, was elected hon. secretary ; and applications for membership were signed by many engineers holding responsible positions throughout Assam. The standard of membership has intentionally been made so as to ensure the acceptance only of qualified men of undoubted ability. This is the second Colonial section of the Junior Institution of Engineers to be established within a year, and indicates that the reputation of this society is continually on the increase.

"All the World's Aircraft."—The tenth annual issue of this publication, which was founded by the late Fred. T. Jane, and is now edited and compiled by Mr. C. G. Grey, shows distinct signs of the relaxation of the hand of the censor, which must have borne heavily upon it for the last five years. Although war-time restrictions were not entirely removed during the period of its compilation, the mass of data available was still sufficient to necessitate careful discrimination on the part of its editor. To make room for new matter several of the features present in the previous volume have been eliminated from the current issue. The whole of the first part of the last volume, including the dictionary, international glossary, table of records, &c., has been omitted, as also have been the historical section, lists of pilots, and the honours list of the Royal Air Force. Of the omissions, we think the table of records will be missed most, but as the volume is already approaching the limits of convenient size, it is unlikely that users will press for the inclusion of any more matter. The first part of the current volume is devoted to aeroplanes, and commences with a preface on the subject of Aircraft in War by Major W. E. de B. Whittaker. The countries are arranged in alphabetical order of nationality, and notes on the developments of naval and military aeronautics are given in each case, as well as illustrated descriptions of all makes of machines in use. The British section, which is naturally most voluminous, gives an excellent insight into the development of the aviation industry in this country during the war. The machines dealt with, however, include a large number of commercial and sporting models, as well as those for military and naval use. There is a marked disparity between the amount of data given for the various machines and this, we imagine, may be taken as an indication of the makers' attitudes towards publication of particulars of their products. The German section of the book is fuller than might have been expected, and is worthy of careful study. It contains a number of photographs which have not been published previously outside Germany. The remainder of the book is divided into two parts, dealing respectively with aero engines and airships. In the former, particulars are given of upwards of 60 different engines arranged alphabetically, according to name. The airship section still suffers somewhat from war restrictions, and is admittedly incomplete as far as foreign countries are concerned. It contains, however, a large amount of interesting and useful material, much of which could not be made public during the war. This issue, which maintains the high reputation, is published by Messrs. Sampson Low, Marston and Co., Limited, of 100, Southwark-street, London, S.E. 1, and its price is 2*l.* 2*s.* net.

ROYAL METEOROLOGICAL SOCIETY.

The first ordinary meeting of the present session was held on Wednesday, November 19, at 6 p.m., in the society's rooms, 70, Victoria-street, Westminster, Sir Napier Shaw, F.R.S., president, in the chair.

Lieutenant C. W. B. Normand, B.F., of the Indian Meteorological Service, read a paper on the "*Effect of High Temperature, Humidity and Wind on the Human Body.*" The climatic conditions under which a wet bulb restricted to a certain maximum rate of evaporation and having an initial temperature of 36·5 deg. C. will neither gain nor lose heat, are derived from kata-thermometer and wet bulb formulæ. The application of these results to the human body are then considered, and on the assumption that conditions resulting in a rise of body temperature above 36·5 deg. C. must be fatal the upper limits to livable climatic conditions are deduced. The scorching and sometimes deadly simoon of tropical deserts is considered to be a case of the onset of a high wind, without necessarily a change of temperature or humidity converting livable into unlivable conditions. The suggestion is also made that an essential feature of heat strokes may be that a portion of the body has been exposed for a time to air conditions which are above the limit for existence. The wet kata-thermometer and wet bulb formulæ were found to furnish quite discordant results regarding the behaviour of a wet surface under varying wind velocities, and it is suggested that this discrepancy is due to a less efficient wetting of the kata-thermometer bulb and to a consequently restricted rate of evaporation from it.

Captain A. J. Bamford read a paper on "*Some Observations of the Upper Air over Palestine.*" This paper gives a brief summary of some upper air observations made in Palestine during the last two years. Tables and graphs are given showing the monthly averages of the horizontal movements at different altitudes over three stations, at one of which (near Ramleh) observations were kept up continuously for a year. Attention is called to the agreement between the results found and the general summary in Professor Hildebrandsson's "Mouvements généraux de l'atmosphère." These flights were observed for the first few (usually 15) minutes with two theodolites, or a theodolite to a rangefinder, the upper part of each ascent being observed with a theodolite alone. The second part of the paper deals with vertical velocities and includes frequency curves, showing for each of the layers 0 ft. to 2,000 ft., 2,000 ft. to 4,000 ft., 4,000 ft. to 6,000 ft., the number of times in each month that the observed velocities differed from the theoretical ones by not more than 10 per cent., 20 per cent., 30 per cent. or 40 per cent., &c. The lowest layer is appreciably the most varied, and in it differences of 50 per cent. are not unusual, although the average velocity differs very slightly from theory. In the other layers there is a distinct increase in the compactness of the frequency curves, while the average velocity changes from slightly below the theoretical value.

A third paper, by Mr. E. G. Bilham, B.Sc., was entitled "*Barometric Pressure and Underground Water Level.*" The results recently obtained from a study of an experimental wall with autographic registration at Kew Observatory, Richmond, Surrey, are compared with some earlier records obtained by Dr. Isaac Roberts at Maghull, near Liverpool, and by Professor K. Honda, in the neighbourhood of Tokyo, in Japan. As at Kew, the sensitiveness of the water surface at Maghull to pressure changes varies considerably, high sensitiveness being associated with saturation of the soil by previous heavy rainfall. In Japan it was found that in surface wells the water level was not affected by pressure changes, sensitiveness being exhibited by deep artesian wells only. Professor Honda has pointed out that by determining the sensitiveness of a well to barometric pressure, the extent to which pressure changes affect strata at a given depth below the surface can be deduced. Data for Japan and the British Isles obtained in this way show marked points of difference.

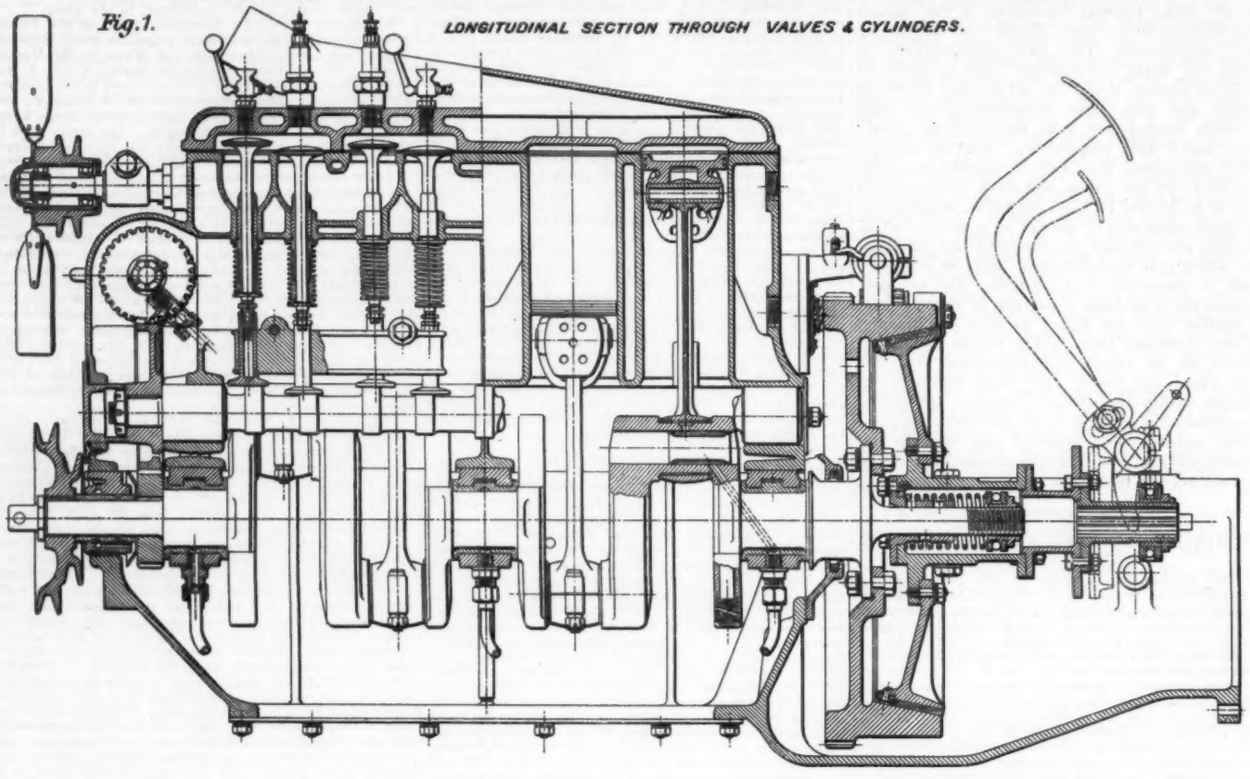
Imperial Institute of Patentees.—At a recent meeting of the Executive Council of the Imperial Institute of Patentees, at 6, Holborn Viaduct, E.C., Sir Harry S. Foster, D.L., was elected president of the Institute, in place of the late Sir Joseph Lawrence. An Administrative Committee was created which will advise and assist the poor inventor and protect his interests in every possible way. All communications and applications for membership should be addressed to the Organising Secretary, Mr. Godfrey Cheesman, 6, Holborn Viaduct, London, E.C. 1.

Improved Tumbler Switch.—Just prior to the outbreak of war Messrs. J. H. Tucker and Co., Limited, of King's-road, Hay Mills, Birmingham, completed the designs for a new pattern of 5-ampere flat type tumbler switch, the mechanism of which gives a quick "make" as well as the usual quick "break" action. Although circumstances arising out of the war prevented the switches from being put on the market in the usual way, they have been supplied in large quantities to various Government departments for war work. These contracts are, however, now completed, and the switches are available for general use. In size and general appearance the new switches are identical with the well-known flat type of switch with quick-break action only, and they are supplied in the usual plain brass or fancy finishes. The switch mechanism, although difficult to explain without illustrations, is by no means complicated, and its reliability may be judged from the fact that, as a test, one of the switches was operated by mechanical means over 2,000,000 times without failure.

14·9-H.P. FOUR-CYLINDER ENGINE FOR MOTOR CAR.

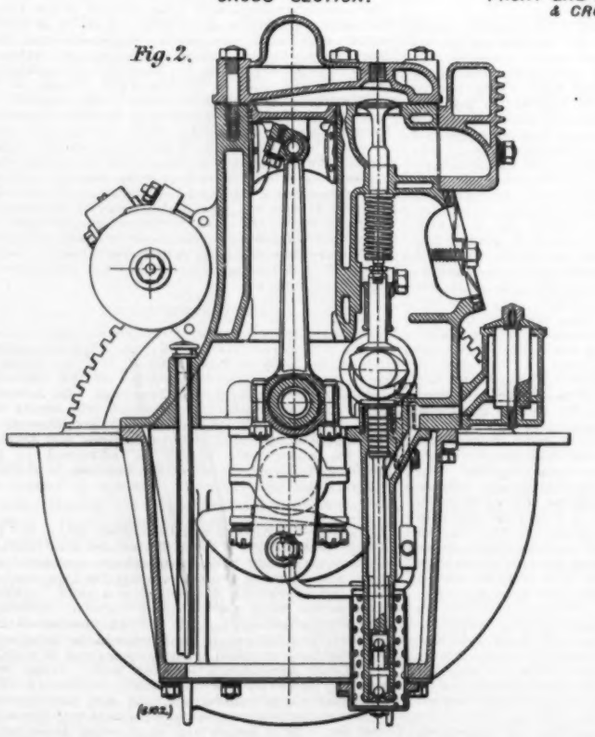
CONSTRUCTED BY MESSRS. J. TYLOR AND SONS, LIMITED, ENGINEERS, NEW SOUTHGATE, LONDON.

Fig. 1. LONGITUDINAL SECTION THROUGH VALVES & CYLINDERS.



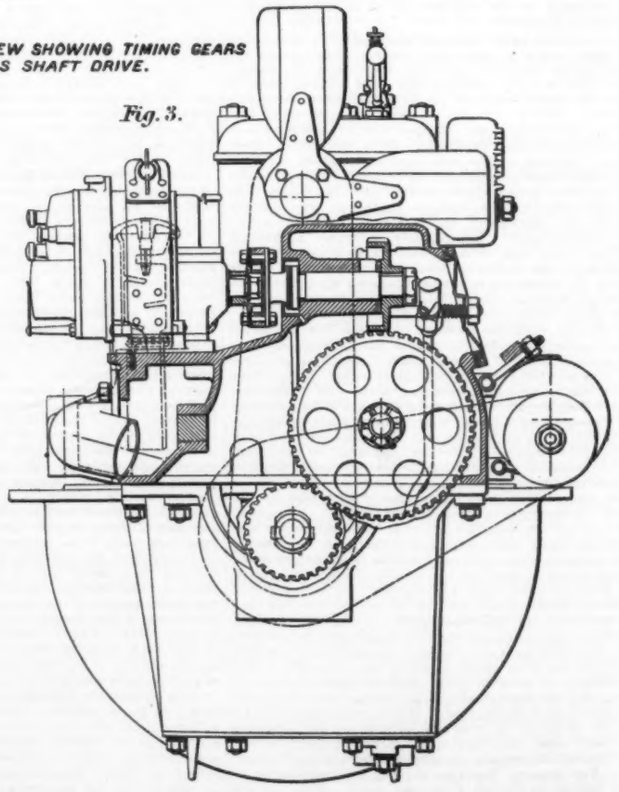
CROSS SECTION.

Fig. 2.



FRONT END VIEW SHOWING TIMING GEARS & CROSS SHAFT DRIVE.

Fig. 3.



☞ One of the most interesting attempts at the tackling of mass production of motor cars on an adequate scale in this country is that which is being made by Messrs. Sir William Angus, Sanderson and Co., Limited, of Birtley, Co. Durham. This firm is working in conjunction with a number of specialist firms, each of which is contributing some one or more items to the whole, the final assembly being carried out by Messrs. Angus, Sanderson. The engines are being supplied by Messrs. J. Tylor and Sons, Limited, who have built a factory specially for the purpose of their manufacture at New Southgate to the north of London. The axles and transmissions are by Messrs. E. G. Wrigley and Co., Limited, of Foundry Lane Works, Soho, Birmingham. The pressed-steel frames are to be supplied by Messrs.

Mechan and Co., Limited, of Glasgow, and the wheels by Messrs. W. Goodyear and Sons, Limited, of Dudley. The electric starter and lighting sets will be of Messrs. J. Lucas and Co.'s make. Most of these firms are well known in connection with one or other branch of motor-car work, and the complete organisation promises well for a successful future. The car to be produced is to be fitted with a four-cylinder 14·2-h.p. engine, and will have a three-speed gear box. A four-seater touring body will be fitted, but, as far as we understand, no attempt is at present being made to standardise the body in the same way as the chassis, and at the recent Olympia Exhibition, several different types of body were on show.

In Figs. 1 to 3 on the opposite page, we illustrate the Tylor engine of this interesting car. It has four cylinders in monobloc, each 3-in. bore by 5-in. stroke, giving a Treasury rating of 14·9 h.p. The engine develops 15·5 brake-horse-power at 1,000 r.p.m., and 38 brake-horse-power at 2,500 r.p.m. It will run at a maximum speed of 3,800 r.p.m. without periodic vibration, and will throttle down to 250 r.p.m. On the bench, the consumption of petrol is 0·68 pints per brake-horse-power hour, and when fitted to the car, the engine averages 30 miles to the gallon. Oil consumption is approximately a gallon per 2,000 miles. As will be seen from the figures, the engine is fitted with a loose head, which can be removed for cleaning and inspection without disturbing any other connections than the water inlet and outlet. The bottom half of the crank case is made with an extended sump, forming a clutch pit, to which the gear-box is directly connected. This extension also carries the pedal-control gear, so that the engine, clutch, gear-box, and controls form a complete unit. Three-point suspension is arranged for this unit—the two front supports being taken from the crank case casting, and the rear one from the gear box. The top half of the crank case and the cylinder block may be removed without disturbing the rest of the unit.

The crank-shaft is a drop forging, and works in three main bearings, which are arranged as separate blocks, and are bolted to the crank case and cylinder casting. They are white-metal lined. The connecting rods are drop-forgings of H section, with white-metal big ends, the white metal being run direct into the forging. The small ends are provided with floating bushes. The pistons are of the Ricardo separated-head, slipper type, and are made of aluminium alloy. They each have two compression rings. The valves are of nickel steel, with the head and stem formed solid. All valves are interchangeable. The tappets are of mushroom form, operating direct on the cams, and are fitted with adjustable hardened heads. The whole of the tappet mechanism is enclosed by an oil-tight inspection door and is open to the interior of the crank case for lubrication. The tappets work in two detachable guide bars, which may be removed through the inspection door. The arrangement of this door can be seen in Fig. 2. The timing gears are of special cast-iron and are of helical form. High-tension ignition is provided, the magneto being driven through an adjustable coupling from a cross-shaft at the front end of the engine. This drive is clearly shown in Fig. 3. A lighting dynamo is arranged on the front near-side of the engine and is driven from the crank shaft by a V belt. It is fitted to the crank case by means of a strap, and is capable of easy removal or adjustment for belt-stretch. A starting motor of the fly-wheel pinion gear type is provided, and is attached in a similar manner to the lighting dynamo.

The induction and exhaust manifold is in one piece, and is bolted direct to the side of the cylinder block. The exhaust portion is provided with lateral radiation fins and the induction portion has a hot spot to assist vaporisation. Water circulation is by thermo-syphon. The clutch is of the internal-cone type, having a leather or fabric friction lining. The clutch cone itself may be easily removed for the purpose of re-lining. It is operated by a central spring, which is enclosed in a grease-tight box, and is provided with a ball thrust. The arrangement is well shown in Fig. 1. A circular clutch-brake is fitted and is operated from an extended flange on the clutch coupling. Lubrication of the engine is by pressure feed, the oil in the sump being drawn through a strainer and circulated by means of a plunger pump. This pump is driven direct from the camshaft. It delivers through an external filter to the main bearings, and thence to the big ends, the main bearings being provided with channels for collecting and distributing the oil to the big ends. The external filter, on the pressure side of the pump, is placed in an accessible position on the outside of the crank-case. The filter element may be easily removed for cleaning. A relief valve is provided, which discharges oil continuously over the timing gears. It may be inspected or removed through the tappet gear cover. An oil filter and vent pipe is provided on the off-side of the engine, and is arranged with an oil-level indicator.

Throughout the design of the engine simplicity and the keeping down of the number of parts has been a main consideration. All superfluous external joints have been eliminated, and a clean design aimed at. Accessibility has been kept in view throughout, and all adjustments and repairs can be effected with facility. The bottom half of the crank case is provided with a large inspection door, through which the big ends can be examined, and, if necessary, the connecting rods, complete with their pistons, can be removed. The oil pump can be detached completely by the removal of two nuts, no pipe connections whatever having to be disturbed. The engine is particularly intended for putting into the hands of the owner-driver who only too frequently is a very amateur mechanic.

UNIVERSITY MATHEMATICS FOR ENGINEERS.

To the Editor of Engineering.

Sir,—The following *errata* escaped notice in correcting the proofs of the writer's letter in your issue of November 7: First paragraph, for "corresponding arc" read "corresponding arc/semi-diameter."

Chrystal's remark that the arc of a hyperbola requires elliptic functions for its expression is, of course, a well-known result, which should have prevented Mellor's blunder.

In the quotation from "Modern Analysis," for "complex member" read "complex number."

In the two examples in parallel, it is tacitly assumed that "x" is "real"; otherwise the conditions of convergence as stated are not necessary and sufficient.

In the left-hand example, line two, the factor $1/2\,i$ should be $1/i$.

At the top of column two, third line, for "odd and even functions of x" read "positive and negative terms."

These slips have reminded the writer how difficult is accuracy when writing *currents calamo*.

If you can find space for a small elaboration of the analogy between the + and − signs and $+i$ and $-i$, it may be pointed out that the substitution of ix for x in a complete integral power series of x, classifies the terms according to the following table:—

Index	Coefficient of n.		Suggested Name for Type of Term.
	Original Series.	Transformed Series.	
$n = 4m + 1$	$+1$	$+i$	Even—Odd
$n = 4m + 2$	$+1$	-1	Odd—Even
$n = 4m + 3$	$+1$	$-i$	Odd—Odd
$n = 4m + 4$	$+1$	$+1$	Even—Even
$n = 4m + 5$ $= 4(m + 1) + 1$	$+1$	$+i$	Odd—Odd
&c.	&c.	&c.	&c.

From this point of view the factors $(+i)$, (-1), $(-i)$, $(+1)$ are seen to form a cycle, just as $(+1)$, (-1) form a cycle or, rather, an alternation, when $(-x)$ is substituted for $(+x)$.

To make our nota ion quite symmetrical, as well as logical it would be necessary to regard $(+i)$, $(-i)$, as *signs* in the same way that $(+)$ and $(-)$ are regarded.

With these four signs and the extended rules:—

$$(+) \times (-) = (-) \times (+) = (-)$$
$$(+) \times (+) = (-) \times (-) = (+)$$
$$(+) \times (+i) = (-) \times (-i) = i$$
$$(-) \times (+i) = (+) \times (-i) = -i$$
$$(+i) \times (+i) = (-i) \times (-i) = -1$$
$$(-i) \times (+i) = (+i) \times (-i) = +1$$

We can drop all question of "real" and "imaginary" quantity, and consider only the "generalised sign" of each term, subject to the above rules.

I am, &c.,
November 10, 1919. A. R. Low.

"THE COOLING EFFECT OF CARBON DIOXIDE IN FLAMES."

To the Editor of Engineering.

Sir,—In your very interesting leading article under the above heading you suggest that the remarkable influence of inert CO_2 on gaseous combustion shown by my experiments may be due to dissociation of this gas on a large scale. You indicate that some such theory is necessary because "the lowering of the temperature is certainly not due to the higher specific heat of CO_2"; and you attribute this view to me.

This, however, is not my view. In my paper dealing with this subject, which you were good enough to publish in your issue of September 5 last, I suggested that the large reduction in temperature and pressure observed when nitrogen was replaced by CO_2 in the inflammable mixtures was probably cont ibuted to by three causes:—

1. The much greater volumetric heat of CO_2 as compared with that of nitrogen (see sections 5 and 11).

2. Incomplete combustion at the moment of maximum temperature or pressure (see sections 5, 10 and 11).

3. Excess of intra-molecular energy in the CO_2 molecules at this period (see section 13).

According to the first report of the British Association Committee on Gaseous Explosions, the volumetric heats of air and CO_2 at 1,400 deg. C. are 5·75 and 11·1 respectively. (It is simpler to think in terms of volumetric heat rather than in terms of specific heat, for in my experiments the nitrogen of the air was replaced by an equal *volume* of CO_2.) Accepting these figures, it is clear that the lowering of the flame temperatures is largely due to the higher heat capacity of CO_2—though I agree, as will be seen from (2) and (3) above, that this in itself is not sufficient to account for the results.

My experiments indicate that there is uncombined gas at the moment of maximum temperature in the CO_2 mixtures. This may be due to dissociation of the CO_2, as you suggest, or it may be due to incomplete combustion, or indeed to both causes. I rather favour the theory of incomplete combustion, but I am not wedded to it. I should very much like to see your theory further developed.

I hope that the view you express in your note on the "Sale of Gas by Calorific Standard," as to the desirability of specifying the nature of the allowable percentage of inert constituents will be recommended by the Fuel Research Board to the Board of Trade. My experiments show clearly the desirability of eliminating inert CO_2 as far as possible.

Yours faithfully,
W. T. David.
New University Club, St. James's-street, S.W. 1,
November 16, 1919.

"CONTINUOUS BEAMS WITH END LOAD."

To the Editor of Engineering.

Sir,—In the current issue of your paper, Mr. Higgs-Walker draws attention to the fact that the "generalised theorem of three moments" for a continuous beam, under lateral load and end load, can be extended to include the deflection of the points of support. I should like to point out that this extension was first published by me in *Aeronautics* in my articles on "The Loads and Stresses in Aeroplanes," on October 23, the proof being given on October 30. In the issue for October 30, Mr. Higgs-Walker will find extensions of the generalised equations to include the case when there are concentrated lateral loads as well as the distributed load, the case when there is a pin-joint within one of the bays, and the case when the two parts of the beam to the right and left of the pin-joint meet at a small angle. Further applications of the same principles to a braced structure with "stiff" joints were given by me in an article in *Flight* last May.

The equation given by Mr. Higgs-Walker is applicable when only one of the supports moves. In general, the last term should read:

$$E\,I\left[\frac{\delta_B - \delta_A}{l_1} + \frac{\delta_B - \delta_C}{l_2}\right]$$

if the two bays have the same moment of inertia. The extension to include offset couples at the points of support is obvious.

Yours faithfully,
John Case.
Magdalene College, Cambridge, November 15, 1919.

"THE HUMAN ELEMENT IN ENGINEERING."

To the Editor of Engineering.

Sir,—I have been very interested by the abstract you give in your issue of the 14th inst. of Mr. J. Hamilton Gibson's presidential address, read before the Liverpool Engineering Society, and I should have been only too delighted to have had the opportunity of hearing this excellent address in its entirety, as well as the discussion which no doubt followed.

As an engineer and draughtsman I should be pleased if you would allow me to make some remarks on certain of the points mentioned, which have long been before my mind, and which I also regard with strong feeling.

Mr. Gibson states that we can afford to neglect alien competition for the present and that there is work for all. I submit that by no means can we afford to neglect alien (presumably Germany and her allies, and possibly Eastern) competition. We must never delude ourselves by ignoring any competition, even temporarily. That is not a wise policy to advance, but rather should we constantly bear in mind the words of an old and trite saying, "always get there first."

That there is work for all is no doubt very true, yet paradoxically there is not work for all just yet, nor for a long time to come. Since the armistice, and up to the present time, and for goodness knows how long in the future, until labour troubles subside, it is a very depressing study to me to watch weekly the long list of capable and well-trained engineers (demobilised and otherwise) under the heading of "Situations Wanted." This list is often as long as, if not longer than, that for "Situations Vacant," for which many capable friends of mine spend much time in writing to present their experience in detail as requested, yet are never vouchsafed even the common courtesy of an acknowledgment.

I first mention this slight rift in the modern lute, as being the only matter wherein I am not in agreement with Mr. Gibson's interesting address, viz., his somewhat optimistic statement that "the well-equipped young man has the world at his feet in whichever direction he elects to turn." It may be so—later on—but it is not so yet. Even a specialist must, indeed, be a very well-equipped young man, to realise the fact of having the world at his feet, by securing a substantial and progressive position at the present time, and the ranks of the specialists seem crowded.

However, to come to the more important things that matter: with regard to the question of joint patents, n common with, no doubt, many others, I have long considered this a burning question, and one for which legislation should be made, which would give the engineer and the draughtsman the assurance of their just dues by conferring upon them the means of securing recognition and financial award for valuable improvements. When

an engineer or draughtsman takes up a position with a new firm, this should be as legally understood as the ordinary week or month's notice on either side. The employee should also have means to enable him to learn whether an employer's negative statement regarding its proved value is correct. It is, of course, the engineer's daily business to improve, and the employer will naturally be concerned to know how the width of the line of demarcation between an ordinary type of improvement and an original one of proved value, is to be determined. An employer must view with alarm, the possibility of his men insisting upon recognition for every little improvement they may make in design or in practice. But it should not be an impossible task for our technical legal men to devise a system which would ensure equity for both sides, and recognition and award as at present practised should not be left to the generosity of the comparatively few individual firms who have instituted these schemes.

I come now to the most important point of all, viz., the question of the pension scheme. It was, and it still is, impossible for a draughtsman or an average engineer, even in his wildest dreams, to hope to put by sufficient to ensure his independence, or some measure of the same, by the time he may expect to receive his professional *congé*. We cannot all be specialists, for there would not then be room for all. Many men are unable to rise in their profession, not by any means from want of ability and experience, but from lack of opportunity and influence, and they are what one might term the great middle class of the profession, consequently they form a very large percentage of the whole.

Those who have risen and those who are specialists, are able to provide for themselves, but the great majority have been restrained by their own inertia and professional temperament, from urging their just claims for a State-aided pension scheme.

We want something better than an individual company's superannuation scheme, where one must perforce remain in that company until the specified conditions are complied with (otherwise perhaps losing all one has paid in), besides having to endure in many cases an objectionable and unjust superior for a long term of years.

Recently one or two unions or societies have sprung into being with the laudable object of improving the status and prospects of engineers and draughtsmen, and with regard to draughtsmen at any rate, the financial position has been improved. These societies can do useful work in consistently presenting to the Government the claims of our professional men to a pension scheme.

It is to be hoped, however, that the members of these societies will keep a firm hand on their executives, and ensure that all questions involving the funds and policy are decided by ballot of individual members, and not carried by a show of hands at a general meeting, or by block votes of delegates at a conference.

The teaching profession have recently been given a pension scheme by the educational authorities, and surely the engineering profession whose training is harder, more expensive and never finished, and whose responsibilities are greater and holidays incomparably less, surely this class of able men should also receive from the Government, means of independance on arriving at the end of their professional career.

Engineers are of greater relative importance to the country than are school teachers, and I sincerely trust it will not be long before we can obtain the same pension benefits as they now possess.

If the Government could be induced to provide such a scheme for the professional engineering class, to come into effect when a man attained the age of, say, 60 years, they might perhaps be further induced to allow those who desired it, to contribute during their most efficient years towards a scheme whereby they might retire at an age as early as 50 years, the advance pensionable amount depending upon the amount contributed, or they might be allowed to augment by such contributions, the pension they would receive at the age of 60 years.

It is not sufficient to put one's trust in insurance companies or in annuities, for the former may become bankrupt and the charges for the latter would be too much for the average professional man where a decent living pension is desired.

Engineers and draughtsmen should be free to enter another firm in order to improve their position and prospects, at the same time knowing that it would make no difference to their pension. We should then retain the initiative due to competition, without the depressing results of time serving.

If you, Sir, on behalf of those to whom this country owes so much, would lend your influential columns towards the furtherance of this just ideal, I am sure you would be doing the greatest service towards reconstruction, as well as earn the great appreciation and heartfelt thanks of an earnest and sincere body of men, whose efforts would be increased, for, after all, it is but natural to give better output when one's mind is free from the eternal question of how to provide for the future.

Yours sincerely,

November 15, 1919. "A.M.I.Mech.E."

THE EMPLOYMENT OF DEMOBILISED ENGINEERS.

To the Editor of Engineering.

Sir,—I have answered dozens of advertisements appearing in your columns and in other journals, which, as a practical engineer holding good pre-war testimonials and having useful experience in a technical corps during war, I am thoroughly competent to fill; but up to the present none of the advertisers have had the courtesy even to acknowledge my letters.

This is not the treatment that a man who has given nearly five years of the best part of his life to help defend the advertisers' lives and businesses, deserves. Mine is no isolated case, and many hundreds of skilled, competent men who are only too eager to help to build up the industries of this country are being treated in the same scandalous way.

Only a few weeks ago I was told point blank by the manager of a large firm that I had better make up my mind to take a job at the bench as a fitter; this after holding positions as foreman or works engineer for over fifteen years

We are continually being told that the working classes are ruining the country by their unpatriotic selfishness in making demands that the industry cannot meet; it appears to me the employing class are equally to blame by the way they are victimising some of the best men the country has produced.

Yours faithfully,

An Ex-Warrant Officer, R.A.F.

"STANDARD SPINDLE NOSES FOR MILLING MACHINES."

To the Editor of Engineering.

Sir,—May we beg the indulgence of a final word on this subject. Referring to the letter in your issue of November 14, page 649, signed by Mr. I. H. Wright on behalf of the Associated British Tool Makers, Limited, we confess to a considerable respect for the experience in heavy milling of the Cincinnati Milling Machine Company, who have designed, and are responsible for, the spindle nose adopted by the above association, but we would respectfully point out that the first experiments in really heavy milling, which showed the necessity for the abandonment of the old screwed spindle nose, were made not in America but in our works, and were fully described in a paper read by the undersigned before the Manchester Association of Engineers, on November 23, 1912.

In this paper full descriptions of the experiments which proved the weaknesses of the old type of spindle nose, were given, and the new nose was then adopted by us after proof that it was a practical and successful design.

At that period practically every maker of horizontal milling machines, both in this country and in America, was using the screwed spindle nose, and continued to use it for a considerable time after the publication of the paper in question. We, ourselves, as a result of the experiments, were so convinced of the defects in the screwed spindle nose, that we at once abandoned it, the taper nose having been used continuously since then with uniformly satisfactory results. The American experiments in heavy milling, which resulted in the introduction of the Cincinnati spindle nose, were undertaken at a much later date, and were probably stimulated by our own experiments, which were pretty widely published.

We feel safe in saying that our own design has been tested for a very much longer period than the Cincinnati design, and that it is a practical success, both for small cutters and for large inserted blade cutters. It may be true that America is supposed to lead in such matters, but we suggest that credit should be given to this country where such credit has been fairly earned. Our criticisms of the Cincinnati spindle nose were given in our last letter published in your journal on November 7, and we do not wish to add anything to them.

With regard, however, to the criticisms of our own spindle nose made in Mr. Wright's letter, we may state that the taper spindle nose is not likely to be bruised, as it is hardened on the taper, and that the effect of a bruise in making a cutter run out of truth, would be the same for any type of nose, whether taper or parallel, so that this criticism could hardly be applied to our taper nose as against any other design.

Experience has proved that the central bolt is not too long or too elastic to keep the cutter firmly seated upon the taper. Our experience has also shown that this taper is not undesirably short and does not act as a spherical joint; cutters of any practical size can be held perfectly firmly and truly on the taper nose by means of the central bolt.

The present position appears to be this: That we have suggested our own series of spindle noses as the basis of a new standard; the Associated British Tool Makers have advocated the Cincinnati design as an alternative. We have criticised the Cincinnati design, and they have defended it and criticised our own; we have replied to their criticisms of our design, so that the matter might well now be left to the judgment of your readers, although we shall be happy to answer any questions as to the manufacture or use of our own type of spindle nose, which we still think is well worthy of consideration as a British standard.

Yours faithfully,

(For Alfred Herbert, Limited),

P. V. Vernon, Director.

November 17, 1919.

The Royal Institution.—The ninety-fourth course of Juvenile Lectures founded by Faraday at the Royal Institution, will be delivered this Christmas by Professor W. H. Bragg, on "The World of Sound." The lectures will be given on the following days at 3 o'clock. Tuesday, December 30, "What is Sound?"; Thursday, January 1, "Sound and Music"; Saturday, January 3, "Sounds of the Town"; Tuesday, January 6, "Sounds of the Country"; Thursday, January 8, "Sounds of the Sea"; and Saturday, January 10, "Sound in War."

TRADE UNIONISTS AND WORK.*

The prime necessity, unless we are cowardly and blindly optimistic, is to face the facts and believe in the call to work. Our adverse trade balance, our sale of securities, our indebtedness to America and the tremendous growth of the National Debt cannot be met by paying doles for idleness and decreasing output. The need of houses, furniture and domestic servants shows that the "no work" cry is fallacious. Nor must we forget the half of the population who cannot work—old workmen, old women, children, pensioners and disabled soldiers. The present unrestricted increase of wages spells disaster for such with four millions of trade unionists able to outbid the poor for the scant food and coal, riding roughshod over the rights and needs of the remaining fifty millions of the population—witness the railway strike of September 26. Unless we work and produce goods to exchange for food, the bulk of the people will be in dire necessity. How grossly unfair is the payment to the out-of-work man of three times what is paid to the old age pensioner.

Trade unionism, in spite of the great work it has done, is now guilty of removing disciplinary safeguards of work by the advocacy of a minimum wage and out-of-work pay. Its powers exploited by extremists, trade unionism tends to become a menace to society at large; why should trade unionists at the National Industrial Council object to the scheme to teach wounded soldiers a trade, or rope round work for their unions and cause such a strike as at Horbury, Wakefield, against employment of non-union returned soldiers? Will labour continue to ignore such facts as these: (1) With a home-grown supply of food sufficient for three months in the year only, along with the increasingly adverse rate of exchange, we must make goods for export not poorer in quality and not greater in price than can be produced abroad; (2) since the passing of the Coal Mines Minimum Wage Act, 1912, there is a decreased annual output of coal per man, from 300 tons before the war to 183 tons now, whereas in the United States of America, in the same period, it has increased from 400 tons to 600 tons; (3) the cost of labour per ton of coal in 1913 was 6*s.* 10½*d.*, now it is 21*s.* 10½*d.*; (4) the pithead price in England is now 29*s.* 4*d.*, in the United States of America 11*s.* 2*d.*, and steel rails, pig-iron, ship plates, are all produced more cheaply there. Restricted output means that everything is dear, employment will be scarce, and our industries will be beaten in the competition with the United States of America, Germany and Japan.

The Institutes of Mining Engineers protested by resolution against basing the Sankey Recommendations on unrestricted evidence from one section, whilst restricting the engineers' evidence to "wages and hours." Many of these recommendations have been operating since March—result, decreased output, increased prices, more frequent strikes and absenteeism. Nationalisation or Government control increases costs to the poor, *e.g.*: (1) Government control of railways has lost not only the 50,000,000*l.* per year pre-war profits, but meant a further annual loss of from 40,000,000*l.* to 60,000,000*l.* (2) Partial Government control of mines meant an annual loss of 50,000,000*l.*, hence its transference to the public in the last 6*s.* per ton rise. Private enterprise gave coal to the people at 7*s.* to 10*s.* per ton, with sufficient profit and margin for good working conditions, improvement of machinery and greater comfort to the workers than in any other industry. Nationalisation would not tend to foster men of inventive genius like Watt, Boulton and Murdock. Are we not facing dangers which beset the Roman Empire? A system of public doles then, as now, encouraged slacking, discouraged undertakings with distant and non-immediate returns, and led to ruin. There is a very large waste of the time, money and energy of business men taken up with the settling of labour troubles, troubles caused partly by Government interferences between employer and employed.

The only remedy is "Back to work," hard work, a far greater output, and abandonment of "ca' canny." To make output equal the demand will end profiteering. Confiscation of capital will not help. Profit-sharing, now that profits are so reduced, will not increase wages appreciably. The function of sound government is to maintain order and, stopping interference which chokes trade, to leave the differences between capital and labour to adjust themselves.

There is no peace in the house where the spoilt child is given everything it cries for. Just so, we have no peace because we give way every time to the wages and leisure the 4,000,000 trade unionists cry for. A grandmotherly government fears a greater row from a united 4,000,000 trade unionists than from the remaining 50,000,000, the greater half being the poorest, of the community. Instead of labour boasting that it has come into its own, would it not be truer to say that its demand for 37*s.* per ton in wages and transport had deprived the poorest of their coal and left their houses fireless, and enabled those who can work to outbid those who cannot work for the necessities of life.

The Registration of Male Employees.—We have received from the Minister of Munitions notice that he now cancels and revokes, as from November 18, 1919, the instructions contained in a circular letter (M.M. 37A), issued in the year 1916, to various establishments, requiring them, pursuant to the provisions of Section II of the Munitions of War Act, 1915, to prepare and keep a register in the form prescribed by the said circular letter of all their male employees over 16 years of age.

* Abstract of address by Mr. W. Price Abell, Wh.Sc., M.Inst.C.E., as chairman of the Derbyshire Society of Engineers, delivered November 17, 1919.

APPLICATION OF PULVERISED COAL IN BLAST FURNACES.*

By E. P. Mathewson and W. L. Wotherspoon.

History of Early Attempts.—The use of pulverised coal in reverberatory furnaces, cement kilns, open-hearth furnaces, boilers and other similar furnaces, has been dealt with extensively in many papers and publications; the present paper on the other hand will be confined to the application of pulverised fuel to blast furnaces, wherein the mixture of fuel and air is injected into the lower portion of a piled mass of material, and combustion takes place under pressure.

Until recently the history of pulverised coal in blast furnaces contained nothing but records of failures. Sir Lowthian Bell, in his book on the "Principles of the Manufacture of Iron and Steel," published in 1872, which deservedly ranks among the world's metallurgical classics, mentions an attempt to introduce finely-divided coal with the blast at the tuyeres in an iron furnace; the attempt was soon abandoned, and Bell remarked that it needed but little consideration to insure the rejection of all such schemes.

About 1902, Mr. W. J. Forster, of Darlaston, England, satisfied himself by a great number of experiments at the Darlaston furnaces: "That nothing but failure can be expected from the addition of cold materials into the hearth of the furnace with the blast."

Possessed of this opinion, Mr. Forster suggested the use in the blast furnace of a specially-prepared carbon obtained by heating solid carbon to a very high temperature, so that all volatile matter and moisture should be expelled and the carbon should be strongly heated before its use in the blast. He obtained British and American patents on the expedient of so preparing carbon and introducing it with the blast, whereby he hoped to make special grades of iron. The idea seems to have produced no effect upon the art of smelting iron, but it may be considered to illustrate the rest of the history of the use of pulverised fuel in blast furnaces, as this history consists of sundry comparable suggestions of expedients all of which have, so far as known, failed to meet with practical success. The efforts to use successfully pulverised fuel in iron blast furnaces have embraced such expedients as the substitution of heated gas, with and without superheated steam, for some or all of the air; the careful classifying of the fuel into different and distinct sizes with a view to employing the finer grade to create a high initial temperature to ignite the rest; the substitution of an annular reverberatory arranged around the base of the charge, and the injection tangentially thereinto of the powdered coal and air; the grinding and mixing of the charge itself so that the particles might fall through a stream of burning fuel and air, and so on. It is not profitable for present purposes to consider all these expedients or the various patents which have been granted on them, because, so far as is known, none of them has been sufficiently successful to secure adoption.

Fig. 1.

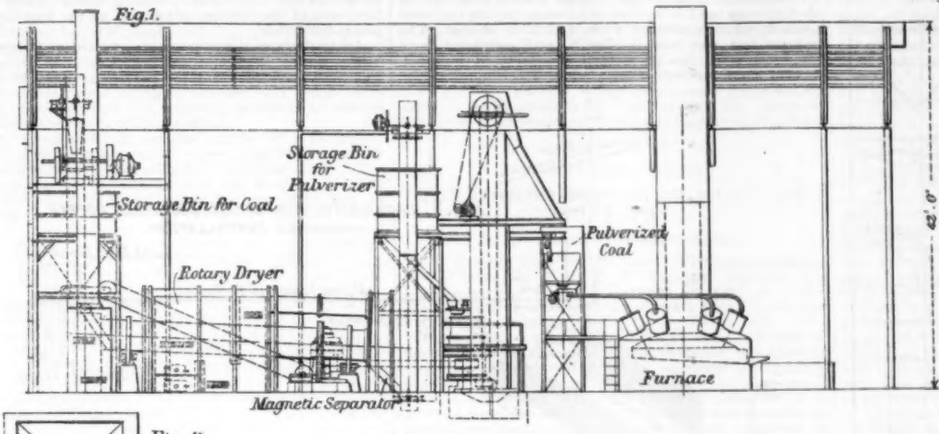


Fig. 2.

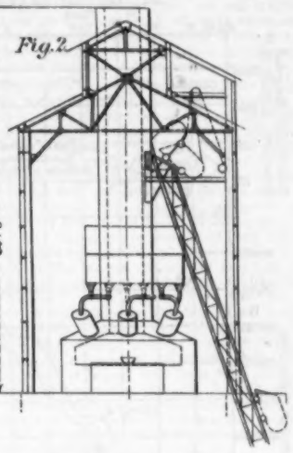
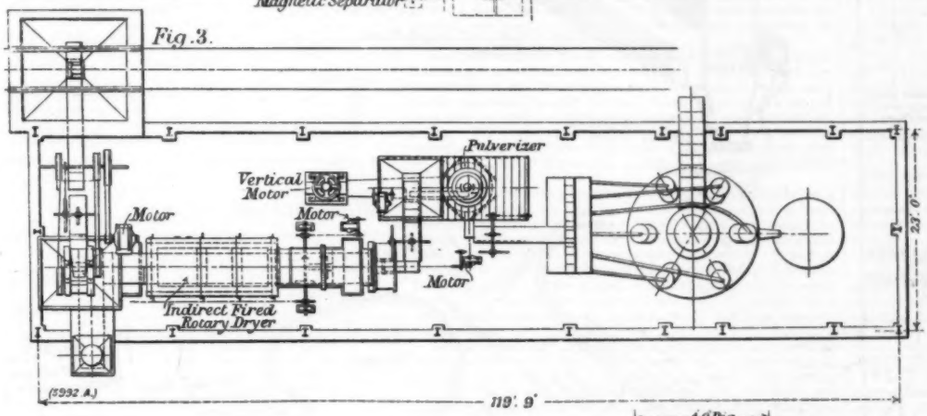


Fig. 3.



The results obtained by the recent work which we shall now describe have been attained not so much by resort to extraneous expedients as by the development of the combustion process itself. The chemical phenomena of combustion are relatively little known, although they have been made the subject of important research work by numerous scientists since the days of Bunsen, who, in 1845, made investigations on a coal-fired blast furnace used for the smelting of iron ores; and it is impracticable within the limits of this paper, to discuss these phenomena in detail. The phenomena apparently embrace distillation of volatile matter, gasification and combustion. When a mixture of air and finely-divided fuel is directed into and against a mass of more or less refractory material, different results may ensue, according to variations in a multiplicity of factors. The work to be described seems to demonstrate that by proper provision of suitable space for combustion, maintenance of correct air pressure and fuel supply with the combustion space, it is practicable to develop within the charge a sort of supercombustion, which provides at greatly reduced cost the heat necessary to bring the charge to a molten condition. It is particularly difficult to generalise or define the possibilities or limitations of the generation of heat in a blast furnace so operated, for much depends upon the physical and chemical characteristics of the charge, as well as upon the variable factors directly entering into the combustion. A better idea of the work may be afforded by concrete illustration.

For this purpose we describe work in a field which, we believe, has heretofore been untouched even by suggestion, namely, the melting of copper and the smelting of copper ores.

Experiments of Garred.—Mr. Garred became interested in the application of pulverised fuel to blast furnaces in 1913, but it was two years later when he applied some of

Fig. 4.

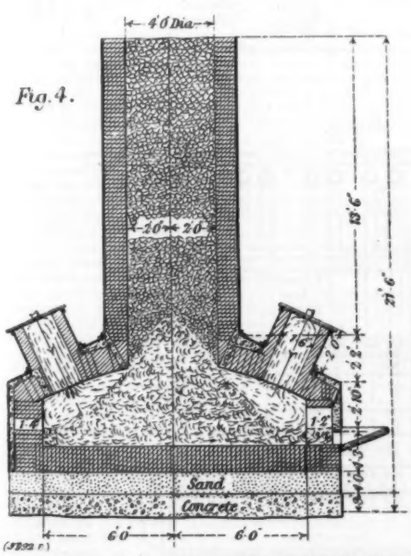
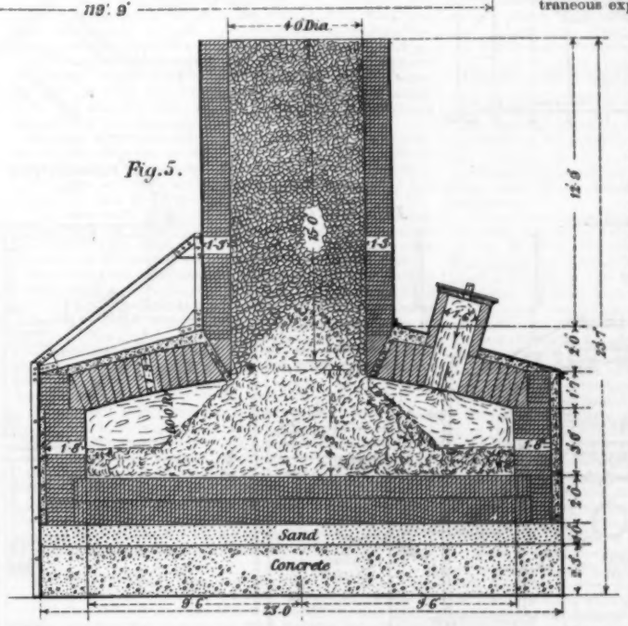


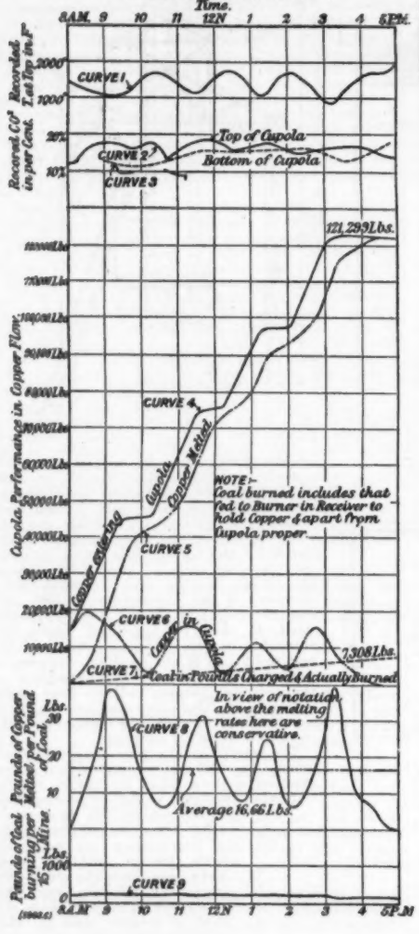
Fig. 5.



* Paper contributed to the Canadian Mining Institute. Part of vol. xxii.

his ideas in a practical way, by melting blister copper in a blast furnace as shown in Figs. 1 to 5. The design provided special facilities for combustion, and the tuyeres were so arranged that in the event of the charge becoming frozen, they would remain clear. During the experiment, over 1,000,000 lb. of blister copper was melted.

Fig. 6. CHART SHOWING OBSERVATIONS RE-EXPERIMENT MELTING BLISTER COPPER.


Time.
8 A.M. 9 10 11 12 N 1 2 3 4 5 P.M.
Recorded CO² in per Cent. Exit Top the Stack
CURVE 1
Top of Cupola
CURVE 2
Bottom of Cupola
CURVE 3
Cupola Performance in Copper Flow
121,299 Lbs.
CURVE 4
Cupola Copper Melted
NOTE—Coal burned includes that fed to Burner in Receiver to hold Copper 4 apart from Cupola proper.
CURVE 5
Coke Charged
CURVE 6
Coke in Cupola
7,308 Lbs.
CURVE 7
Coal in Pounds Charged & Actually Burned
Pounds of Copper Melted per Pound of Coal
In view of notation above the melting rates here are conservative.
CURVE 8
Average 16.66 Lbs.
Pounds of Coal burning per Min.
CURVE 9

Experiments at the Tennessee Copper Company's Smelter.—Experiments at the smelter of the Tennessee Copper Company were decided upon early in 1918, one of their standard blast furnaces, 22 ft. 6 in. long by 60 in. wide, being used. Ten tuyeres on one side of the furnace were equipped for the use of pulverised fuel, and the first test run of importance started on April 22 and was continued until May 4, during which period the percentage of coal to the charge was 3·8 as against 5·7 of coke used on the other furnaces during the same period, when operating with a similar charge. The second test run started May 9, and continued until May 24, when the percentage of coal used was 3·6, a very small amount of coke being used intermittently.

A third test run was then made, feeding a little coke on the side of the furnace where no coal was fed previously as it had been found there was a tendency for crusts to form on that side of the furnace. It was then decided to apply the coal at 10 tuyeres on each side, but experimental work was postponed, owing to the possibility of some unconsumed carbon in the furnace gases causing discolourisation and affecting the quality of the acid, which is an important product of the company, particularly during the war, when a portion was used in the manufacture of high explosives. The war requirements in this connection no longer existing, the company returned to the experimental work in January, and are continuing, with various modifications, the methods of applying the coal.

As the Tennessee company had not used pulverised coal previously, it was necessary to instal a coal preparation plant. A plant with a capacity of 3 tons per hour was constructed at a cost of about 35,000 dols. The cost of the feeding apparatus at the furnace was about 5,000 dols.

An analysis of the average ore smelted at Copperhill, Tenn., during 1918, is as follows: Cu., 1·55 per cent.; Fe., 34·6 per cent.; S., 24·6 per cent.; SiO_2, 20·3 per cent.; CaO, 4·9 per cent.; MgO., 2 per cent.; Zn, 1·4 per cent.; Al_2O_3, 4·3 per cent.

The furnace has 27 tuyeres on one side and 24 on the other and the air blast is maintained at 35-oz. to 45-oz. pressure.

Figs. 7 and 8 present a general arrangement showing the method of applying pulverised fuel to the experimental furnace.

Experiments at the International Nickel Company's Smelter at Copper Cliff, Ontario.—Following the work of

Fig. 9. DIAGRAMATIC VIEW OF COAL DUST FIRED COPPER FURNACE INSTALLATION.

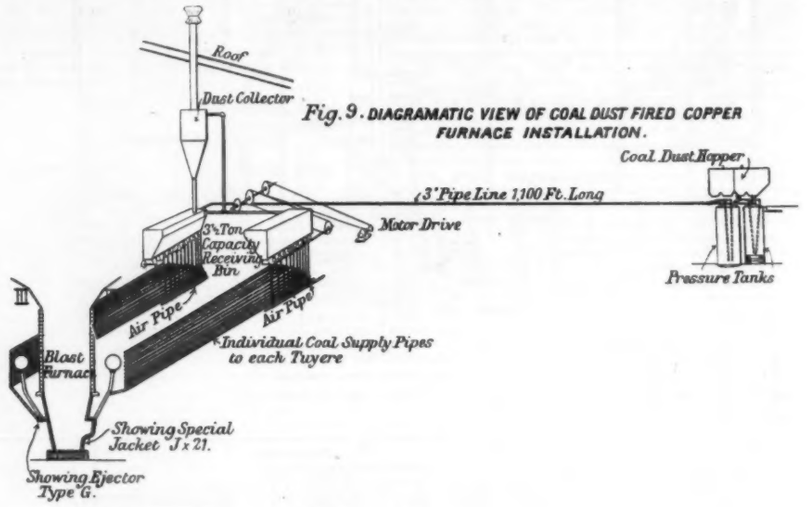


Fig. 10.

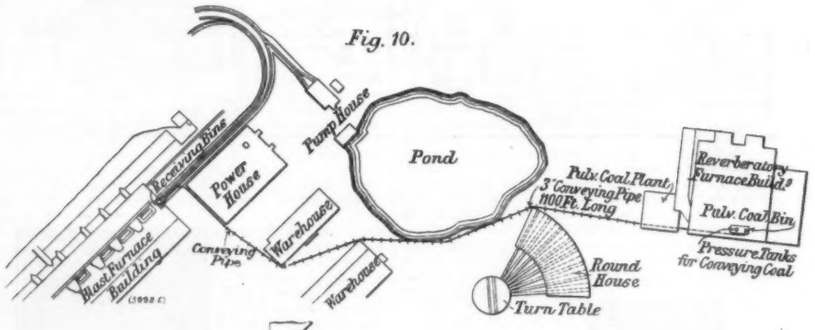


Fig. 7.

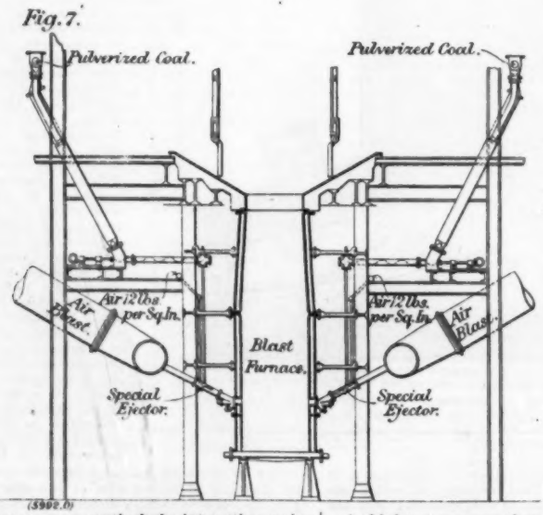
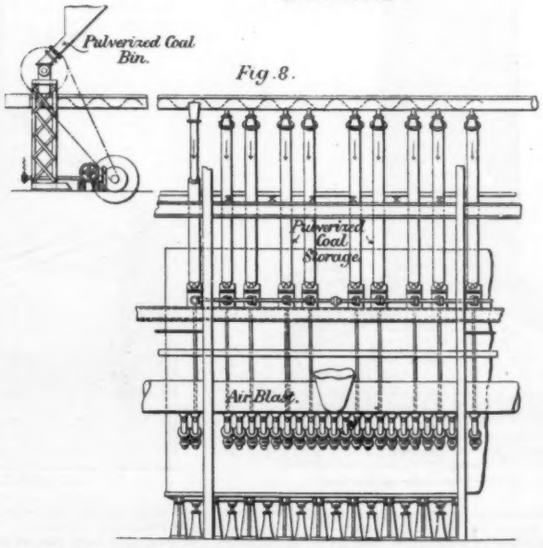


Fig. 8.



The experiments were particularly interesting owing to the fact that with a furnace of 36 in. diameter, handling large angular pieces of blister copper, it was possible to continue the work to the extent described. Data of observations taken during a test run are shown on Fig. 6.

In connection with the danger of a charge becoming frozen it might be mentioned that the furnace was allowed to stand over a week end, and was then successfully restored to its normal condition in a short time by the use of pulverised fuel.

Garred, already described, the International Nickel Company decided, in June, 1918, to carry out experiments in the blast-furnace department of their smelter at Copper Cliff, Ontario. It was decided to utilise one of their standard blast furnaces, which are 25 ft. 6 in. long by 50 in. wide. The furnace bottom is lined with magnesite brick to within 14 in. of the centre of the tuyeres; the two lower rows of jackets are cast-iron with water-cooled pipes, and the two upper rows of jackets are of the standard water-cooled steel type. The furnace has forty-eight 6-in. tuyeres, 24 on a side, spaced about 12-in. centres. These are connected to a main bustle pipe with 6-in. galvanised branch pipes fitted with canvas sleeves. The bustle pipe is supplied, by an offset, from the main delivery pipe which feeds seven other furnaces, the normal pressure of air carried at the tuyeres being 23 oz. to 24 oz.

The furnace charge consists mainly of a refractory copper-nickel sulphide ore, a large proportion of which is delivered from the company's roasting plant. The composition of the charge and the average size and analysis of the constituents and products are as follows:—

	Percentage of Charge to Blast Furnace. Average, Six Months.
Roast ore	74·8
Raw Creighton	2·8
Raw Crean Hill	8·0
Total ore	85·6
Converter slag	10·2
Converter scrap	3·2
Limestone and quartz	1·0
Total	100·0

Screen Tests.

	Per Cent.
Roast ore—on 1½ in.	53
Roast ore—on 1 in.	16
Roast ore—through 1 in.	31
Raw Creighton, practically all through ¾ in.	

Typical Composition of Blast-Furnace Charge and Products.

—	Cu.	Ni.	Fe.	S.	SiO_2.	Al_2O_3	CaO.	MgO.
	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.
Roast ore ..	1·40	4·10	38·50	11·75	20·25	4·50	2·25	2·50
Raw Creighton ore	1·40	3·90	39·50	23·00	21·00	5·25	2·50	3·00
Raw Crean Hill ore	2·50	1·75	24·00	11·50	32·00	10·00	5·00	5·50
Converter slag	1·00	3·00	47·00	2·40	26·75	3·00	1·25	1·50
Scrap charged	2·25	6·00	42·00	2·00	21·75	2·00	0·75	1·50
Limestone ..	—	—	1·00	—	2·50	—	52·75	1·10
Quartz ..			3·00	—	91·00	2·90	1·00	1·00
Bl. Fur. Matte	5·85	14·35	48·40	26·25	(6 mos. avg.)			
Bl. Fur. slag ..	0·16	0·32	40·90	1·65	33·15	6·50	3·70	2·50

The furnace, under normal conditions of smelting, treats about 500 tons of charge a day, utilising 60 tons of coke; the average coke consumption for six months being 12·5 per cent. of the charge.

Regarding air conditions, only approximate estimates were available, owing to the whole of the blast furnace plant being supplied from a central blower installation. General observations indicated that the furnace charge is kept about 7 ft. deep, and the smelting zone is from 2 ft. to 3 ft. above the tuyeres. Blow holes form quickly after a fresh charge, but the amount of dust made is about normal, viz., 1·5 per cent. to 2 per cent. to the ore.

The tuyeres require punching regularly, the method being to remove the tuyere cap, and by introducing a rod, to ease the ore in the vicinity of the tuyere. It was usual, when cleaning these tuyeres, for some loose ore to be blown out on the furnace floor in a condition which indicated that the ore close to the tuyeres had not been strongly heated. Through the tuyeres, the charge appeared black and usually there was no appearance of fire until near the middle of the furnace.

The usual practice is to make up a furnace charge consisting of certain proportions of roasted ores, green ore, by-products, such as converter slags and coke—all being dumped into the top of the furnace from small cars in such a way as to give an even distribution in the body of the furnace. Under these conditions of intermittent charges of the fuel, the regularity of its distribution is not easily obtained.

Arrangements for conducting the experiments were greatly facilitated because the company had utilised pulverised coal in reverberatory furnaces since 1911. The coal preparation plant, however, was 1,100 ft. from the blast furnace, and the first problem was how to transmit the coal (Figs. 9 and 10). Attempts were made to transmit the coal in pipes by means of ejectors, but although the results obtained were interesting, they did not meet the particular problem satisfactorily.

Compressed air was then used for displacing the pulverised coal from storage tanks, and it was found that 2½ tons of coal could be transmitted in 5 minutes through a 3-in. standard wrought iron pipe, 1,100 ft. on the horizontal and with an elevation of 50 ft.

The feed or service bins at the blast furnace are about 13 ft. long, 3 ft. wide at the top, 14 in. wide at the bottom, and about 6 ft. deep. They are constructed of No. 14 gauge steel plate, and are completely closed, a manhole being provided, and an air vent pipe to which a cyclone separator is fitted. The bins each hold about 3½ tons of pulverised coal. At the bottom of each are 12 common screw feeders, operated from a line shaft through bevel gears, each feeder having a small clutch; the line shaft being driven from a variable-speed motor. The feeders can be operated satisfactorily at speeds between 40 r.p.m. and 100 r.p.m., to deliver from 3 lb. to 6 lb. of coal per minute; and any individual feeder can be stopped without interfering with the general operating conditions. The screws are made of special length and pitch, being made in a lathe, and in calibrating these at different speeds for the discharge of the coal, no flushing effects have been noticed. This arrangement of feeding the coal is positive, sufficiently accurate and mechanically simple. The 12 feed screws at each bin discharge the coal into 1½ in. diameter pipes, which are in turn connected with the blast pipes or tuyeres at the furnace, the coal being transmitted by ejectors, using a small quantity of high-pressure air, which is beneficial in the mixing of the fuel and air for the furnace.

(To be continued.)

THE ELECTRIFICATION OF MAIN LINE RAILWAYS.*

By Mr. Roger T. Smith, President.

The Railway Electrical Engineer.—The new conditions arising from the Ministry of Transport Act and the Electricity Bill, when it becomes an Act, obviously affect the use of electricity by railways, both for traction for power, and for lighting.

Electrical development on railways there is bound to be, not only on account of its advantages, but because the use of electricity for many purposes is becoming the fashion. Should the amount of electrical engineering carried out by the railways increase considerably, it is of importance to everybody that such work should be carried out and maintained by electrical engineers of standing in the profession.

Electric traction and the application of electrical machinery to all sorts of railway requirements, and the handling of goods at ports and in goods stations and yards, are still largely pioneer work requiring a sound engineering training and a high order of mental attainment. No engineer ought to be responsible in fact for carrying out work involving many hundreds of thousands or even millions of pounds, unless he is also responsible in title.

The construction of railways by the civil engineer, and their equipment by the mechanical engineer, have been carried out by men standing high in their profession, to whom the spending of large sums of money and the design of the work could be safely entrusted. This has become a railway tradition, and unless that tradition is to be broken in electrical engineering, the work ought not to be wholly designed and carried out either by a consulting engineer or by the designing staff of a selected contractor.

Railway electric traction and the design of electrical machinery for dealing with goods and goods wagons require as much skill and training as any work falling to the lot of the electrical engineer. If therefore the railway engineering tradition is to be continued, the man responsible for the design and maintenance of railway electrical work must be a first-class man, and no first-class man will long be content to be a subordinate in another department. It is to be hoped that every railway carrying out important electrification schemes will, if it has not done so already, create an electrical department for the purpose.

Railway Structure Gauge.—Sir John Aspinall a year ago in his address as President of the Institution of Civil Engineers expressed the view that the pressing question to be faced on British railways was that of the increase in the structure gauge.

The structure gauge determines the loading gauge which fixes the greatest cross-section of the rolling-stock and anything it may carry. Sir John pointed out that there are 66 different loading gauges on British railways.

Since without increase in our structure gauge foreign rolling-stock could not run over our railways, and that our limited and various structure gauges were the main difficulty in the way of improvement in all sorts of directions making for economy in transport and in the standardisation of rolling-stock, including locomotives, Sir John Aspinall urged that it was a national matter, and that the structure gauge should be increased throughout the country at the national cost.

Should this matter be undertaken by the Ministry of Transport, it is hoped that provision for the overhead equipment of railways for electric traction will not be overlooked. The various considerations urged by Sir John Aspinall for increasing the structure gauge may not essentially apply to an increase in height. But low overhead structures—tunnels, bridges, station roofs and the like—have always hampered the fixing of overhead electric conductors for traction, and it is important in considering the general case that this should not be left out.

Strength of Draw Gear and Traders' Wagons.—The electrification of railways crossing mountain ranges in the United States and elsewhere have shown the ability of the electric locomotive to haul heavier mineral and goods trains up grades at higher speeds and with fewer locomotives than with the steam locomotive.

In this connection a matter of great importance is the decision under the Ministry of Transport Act to acquire traders' wagons, which roughly form half of the 1,250,000 wagons in use on our railways. Privately-owned wagons, of which it is estimated that 90 per cent. are coal wagons of from 10 tons to 12 tons capacity, are built to a specification issued by the Railway Clearing House. Draw gear is supposed to be tested to 50 tons and to be worked at 12½ tons and to be maintained at that strength, but the frequent breaking of couplings at much lower draw-bar pulls show that this is not done.

If heavier goods trains, and especially mineral trains, are to be hauled by electric locomotives at increased speeds, the strength of the draw gear on all wagons must be increased and maintained at that increased strength, while continuous brakes must be fitted to the fast mineral trains, which is obviously not a requirement that could have been imposed on the trader owners.

Within the limitations of the present structure gauges and the strength of bridges, the greatest dimensions of the steam locomotive, which determine hauling capacity, have been reached, but that capacity on at least one railway amounts on the level to a 1,600-ton load (inclusive of wagon weight) at a high speed. If consisting of 10-ton or 12-ton wagons, such a load would be formed by about 100 wagons and the train exceed one-third of a mile in length. Should the structure gauge be increased, the power of the steam locomotive could also be increased, and the limitation of weight of train which could be hauled would be more emphatically than it is now the strength of the wagon draw-gear and not the capacity of the steam locomotive, which has only reached its limit on gradients.

There is a further limitation to the maximum length of mineral or goods train which can be hauled in the length of lay-by and reception sidings. Many of these are made for only 60 wagons or at most 80 wagons, and it is earnestly to be hoped that in laying out new reception sidings and especially "hump yards," where the sorting of wagons is done by gravity, the importance of accommodating trains of at least 100 wagons or more in length will be recognised, if the electrification of goods lines is to be profitable.

Only some of the conditions at present limiting the use of long and heavy goods and mineral trains at high speeds have been briefly stated. Small-capacity coal wagons limit the train load very greatly, but where wagons have to pass under a coal screen in order to load, very few collieries in the country have screens high enough to take more than the 10-ton or 12-ton wagon.

Enough has been said to suggest that in this country, unlike the United States, many things have to be changed before electric traction can assert its full advantage in hauling heavier goods trains, though increased speeds could be obtained at once. And these changes will take years to carry out.

Economics of Railway Electric Traction.—If, then, mineral and goods traffic is to be hauled electrically under present conditions of size of wagon, strength of draw gear and capacity of sidings, it must be because it is more economical in the cost of haulage, and the same applies to passenger traffic which is without these limitations.

There is, however, an exception to be made to the above statement in the case of mineral traffic down valleys where gradients are steep. This is the case of the Shildon and Newport mineral line electrified by the North-Eastern Railway.

In such cases the maximum hauling capacity of the steam locomotive is not sufficient since the train of full wagons which came down the grade may have to be divided into two or even three trains of empties before these can be taken up the grade. The saving in locomotives, in locomotive crews, and in time far exceeds any saving in cost of haulage, and railways may confidently embark on the electrification of mineral lines with steep gradients even when electricity is not cheap.

The steam locomotive which can haul 1,600 tons on the level cannot haul one-third of this load up a gradient of 1 in 50 at a convenient speed, while within the same load gauge an electric locomotive can be made to haul the 1,600 tons up 1 in 50, or if need be double this load, provided the draw-gear is strong enough.

Electrical engineers, and others, not engaged on railways are at times liable to forget that railways are not run by the engineering but by the traffic department. The traffic department has gradually built up its requirements to suit the needs of the travelling public and the trader, and it is those requirements that the engineer has to meet.

In many directions electric traction provides entirely new possibilities which the traffic department has yet fully to realise. To make use of these new methods the traffic department has first to adapt its ideas and habits to the changed conditions and next to carry the travelling public and the trader with it. No small measure of imagination is required by a railwayman to grasp quite new conditions of service and to do so with the enthusiasm of the propagandist.

Main Line Electrification.—In discussing the economies of electric traction on railways I propose to consider only the locomotive and the train it hauls, to analyse its running costs with steam and to see if electricity can introduce such economies in working costs as to warrant its use. Until the new possibilities with electric traction are understood and gradually adopted no appreciable alteration to traffic costs is to be expected, and in the following analysis traffic costs will be taken as unaltered.

Consider the question of superseding the steam locomotive by the electric locomotive both for passenger and for goods services throughout the railways of Great Britain.

When supplied by electricity from central stations using modern large turbo-alternators enjoying such diversity of load that the power factor is above 30 per cent., the coal burnt in the furnaces of the boilers to produce a given haulage effect on the railway by means of an electric

* The concluding part of the Presidential address delivered before the Institution of Electrical Engineers on November 13, 1919: the earlier part of the address is dealt with in a leading article in this issue.

locomotive is at most 40 per cent. of the coal burnt in the furnace of a steam locomotive to achieve the same result. To a nation which has largely paid for its imported food by its exported coal and has built up all its manufactures and most of its trade on the foundation of cheap coal, I need not remind you, now that coal has ceased to be cheap, how important the saving on the railways of between 7,000,000 and 8,000,000 tons of coal each year would be could it be achieved.

It has been roughly estimated that to electrify all the railways in Great Britain would cost some 300,000,000*l.*, and if coal ever rose to 45*s.* per ton the saving of 7,000,000 tons per annum would of itself pay 5 per cent. on the investment.

The last statistics published by the railways under the Railway Accounts and Returns Act, 1911, were for 1913. If in these returns the working costs per steam locomotive are compared for several large railways running more than 12,000 passenger, goods and mineral train-miles for each mile of route over which the locomotives of each railway work, it is found that these costs are very similar. Average costs for one typical main-line railway are therefore a rough indication of the costs for the others. They may, however, be quite misleading for railways whose traffic is mainly passenger or for railways where goods or mineral traffic largely predominate.

The figures in the analysis which follows have little intrinsic value in themselves but indicate tendencies, and that is all that is claimed for them.

On the typical railway chosen there are roughly 50 per cent. more passenger train-miles than goods train-miles run and twice as many goods locomotives as passenger locomotives used to run them.

The cost of running a passenger locomotive in 1913 averaged over the year and the railway was 1,240*l.* Of this amount superintendence: lubricants, small stores and miscellaneous; repairs, renewals and depreciation; together with interest at 5 per cent. on the cost of the locomotive amounted to 780*l.* and coal and water to 460*l.*, which is 37½ per cent. of the whole.

The average number of passenger train-miles hauled by each locomotive per annum was 27,000 and the cost per train-mile for coal and water was 4*d.* and for the other items 7*d.*, making a total per train-mile of 11*d.*

The cost of running a goods locomotive in 1913 averaged over the year and the railway was 1,020*l.* Of this amount superintendence: lubricants, small stores and miscellaneous; repairs, renewals and depreciation; together with interest at 5 per cent. on the cost of the locomotive amounted to 770*l.*, and coal and water to 250*l.*, which is 24½ per cent. of the whole.

The average number of goods-train miles hauled by each locomotive per annum was 10,000, and the cost per train-mile for coal and water was 6*d.* and for the other items 1*s.* 7*d.*, making a total per train-mile of 2*s.* 0½*d.*

During the present year the cost of coal has increased by 148 per cent., and all the other items making up the working costs, except interest, have been increased by percentages ranging from 120 to 212, so that now the working cost of the train-mile for passenger service is 2*s.* and the working cost of the train-mile for goods and mineral service is 4*s.* 8*d.*

Experience in America and elsewhere has shown that the annual passenger train-miles per locomotive would be increased from 27,000 with steam to at least 40,000 with electricity, and the annual goods train-miles per locomotive would be increased from 10,000 to at least 20,000. Taking these minimum increases and assuming also that the total of all the working costs other than coal and water were the same as for steam, which is not in favour of the electric locomotive, these items come to 10*d.* for the electric locomotive passenger train-mile and to 1*s.* 8*d.* per electric locomotive goods train-mile.

Subtracting these costs from the total steam train-mile costs of 2*s.* and 4*s.* 8*d.* respectively for passenger and goods service, there is left, per electric locomotive train-mile, 1*s.* 2*d.* for passenger service and 3*s.* for goods service to pay for electricity and also to pay interest on the cost of the electric locomotives and of the electrical equipment—substations, the track conductors, section switches and bonding of the rails.

Considering first the interest on the capital required for electrical equipment, Mr. F. W. Carter in a recent communication to the Press* estimates that with high-pressure direct-current equipment the cost of electrifying a railway where, as in Great Britain, there is on the average one steam locomotive per mile of route (which is the case for the type of railway considered) is approximately double the cost of the electric locomotives required. He also states that the cost of an electric locomotive is 2½ times the cost of the steam locomotive for equal draw-bar pull and speed.

The average capital cost this year of a steam locomotive may be taken as 7,000*l.*, so that for each electric locomotive required on the railway its capital cost, exclusive of power house and high-pressure transmission, will to-day be some 35,000*l.*

In that figure no credit has been taken for displaced steam locomotives, nor on the other hand does it include anything for structural alterations which it has been already urged should be made at the cost of the State since much larger interests than electrification are involved.

If the revenue earned by the train mileage hauled by each electric locomotive has to pay interest at 5 per cent. on the capital cost of the equipment, then each passenger locomotive hauling 40,000 train-miles per annum must earn 10½*d.* per train-mile and each goods locomotive hauling 20,000 train-miles per annum must earn 1*s.* 9*d.* per train-mile to pay interest on electrical equipment including locomotives.

The earnings for both interest and electricity were per passenger train-mile 1*s.* 2*d.* and per goods train-mile 3*s.*, consequently each passenger electric locomotive has 3½*d.* and each goods electric locomotive has 1*s.* 3*d.* left per train-mile for electricity.

I shall show later on that where in this country railways generate their own electricity the annual one-hour load factor (*i.e.*, the maximum load averaged over one hour) does not exceed 40 per cent. except in one special and unique instance. If, however, railways can obtain electricity from power stations with great diversity of load reaching a maximum value of not less than 50,000 kw., it may be possible to generate with a load factor of about 50 per cent., and under these conditions even at recent prices electricity for traction should be able to be bought for ½*d.* per k.w-hour at the generating station.

At this price the 3½*d.* and 1*s.* 3*d.* available respectively per passenger and goods electric locomotive will provide 7 kw.-hours per passenger train-mile and 30 kw.-hours per goods train-mile.

Assuming 40 watt-hours per ton-mile as an average for passenger service, the average weight of passenger train including the locomotive would be only 175 tons.

Assuming 30 watt-hours per ton-mile as an average for goods service, the average weight of goods train including the locomotive would be 1,000 tons.

The assumptions made in this analysis are numerous and doubtless controversial, but for the type of railway taken they are the same for the passenger and for the goods electric locomotive with the exception of the annual train-miles worked, for which we must go abroad for our figures. It is for the traffic department to say what average weight of train would be required to be hauled by an electric locomotive, but in order to earn the present revenue per train-mile the average passenger train including its locomotive should be more nearly 275 tons than 175 tons, while the goods train of 1,000 tons is of course much heavier than is hauled in this country as an average.

It has been already pointed out that this analysis only indicates tendencies, but I think it may be claimed that basing the working costs of each kind of locomotive, steam and electric, on the average train-miles hauled in a year, and placing the known increase in train-miles hauled by an electric locomotive at reasonable figures for passenger and goods respectively, the passenger electric locomotive might have difficulty in earning sufficient revenue to meet all present charges and have enough to spare to pay for electricity and for interest on the electrical equipment, while the goods locomotive could much more than do so, provided in both cases electricity is bought or produced by the railway at ½*d.* per kw.-hour at the generating station. I must, however, insist once more that in an analysis of this sort the actual conclusion come to, which is in the form of the weight of passenger train and of goods train (including the locomotive) that can be hauled for the same working expenses now necessary for steam traction, has no intrinsic value and if applied to any individual case might be most misleading. All that the figures show is that in a typical case for the same working expenses now incurred by steam traction, electrification is more in favour of goods haulage than of passenger haulage, and among the railway economies necessary to pay the enormously increased working expenses the electrification of goods and especially of mineral lines ought to receive due consideration.

Present Use of Electricity by British Railways.—With the exception of the 18 route miles of mineral line already referred to between Shildon and Newport which has been electrified by the North-Eastern Railway with great success, all the electrified railways in this country are of the suburban type in that they are worked on the multiple-unit system, each unit consisting of a motor coach hauling or pushing one, two or three trailers, these units being made up into trains of any length required to suit the traffic conditions, capable of being driven from either end whatever the formation may be.

The feature of all suburban electrification replacing existing steam haulage has been first to restore a decreasing traffic, in cases where it had decreased, and then to increase the traffic. Figures for several such cases have been published and I only propose to add some particulars given me by Sir Herbert Walker for the London and South-Western electrified suburban system. The length of route electrified is 49 miles and the length of single track is 152 miles.

Data of the number of passengers carried during seven 12-monthly periods are given on Table I and in diagram on page 699. To summarise this table, between 1913 and 1915 the total number of passengers carried annually by steam trains fell from 25,000,000 to 23,300,000, or 7 per cent. The first electrified section started in October, 1915, and the number of passengers carried in 1916 showed an increase of 26 per cent. over the previous year. In 1917, when the programme of electrification was complete, the number of passengers carried showed an increase of 41 per cent. over 1915. and during 1918 an increase of 73 per cent. over 1915. The passengers carried last year amounted to over 40,000,000 with a car mileage of 5 per cent. less than in the previous year. During this year so far the 1913 figures have been more than doubled.

The London and South-Western Railway electrification has proved satisfactory not only in averting and restoring a diminishing traffic but, assisted by war conditions, has been used to its utmost capacity and proved a most valuable additional facility for the Government in meeting the restrictions placed on road motor traffic.

In Great Britain at the end of 1918 as at present there were 351 miles of railway route electrified, equivalent, with sidings, to 834 miles of single track. By the courtesy of the general managers of fourteen of the leading British railways using electricity for traction, lighting and power, I am able to give the total amount of electricity used for such purposes by these railways during last year. Table II giving these totals will be found on page 699.

Also through the good offices of Mr. H. M. Hobart and the public-spirited energy of Mr. Oehler, one of the associate editors of the New York *Railway Age*. I am able to give you similar figures for eight of the railways in the United States.

The information may be taken as fairly representative, but unlike that given for British railways it is very far from being complete. Moreover, it includes no underground railways. Six out of the eight railroads are trunk lines where the majority of the traffic is hauled by steam locomotives and about half of the 2,762 miles of single track for which figures are given is main-line electrification.

For the eight railways in question during 1918 the electricity used for traction was 478,000,000 kw.-hours with an annual one-hour load factor of 46 per cent. Almost exactly half of this electricity was bought at an annual one-hour load factor of 49 per cent., while that generated by the railways had a load factor of 42 per cent. For lighting and power 164,000,000 kw.-hours were generated and bought at an annual one-hour load factor of 44 per cent.

It will be noticed that in every instance the load factor is better than on British railways, being above rather than below 40 per cent.

Sixty-eight American railways possess 760 workshops, two-fifths of which generate their own electricity for power, and a total of 366,500 h.p. is connected to the supply. The Institution will, I know, appreciate the kindly feeling which allows of the publication of these few details.

On the 14 British railways, which possess all the electric traction and by far the greater part of the use of electricity for other purposes in this country, the total kw.-hours used during 1918 for traction were 400,000,000 and the kilowatts of maximum demand averaged over an hour were 123,000. Consequently the annual one-hour load factor was 37 per cent. Ninety per cent. of the electricity was generated by the railways at an annual one-hour load factor of 41 per cent. The remaining 10 per cent. of the electricity was bought and from the figures of maximum demand given, which are generally difficult to estimate, the load factor is 19 per cent.

The important point is that for suburban services, many of them continuous for 20 hours or more, the greatest annual load factor which has been obtained

TABLE I.—LONDON AND SOUTH-WESTERN RAILWAY.

Number of Passengers (Including Season-Ticket Holders) Travelling on the Suburban Electrified System, Exclusive of those Travelling only between Waterloo and the City.

Year.	Haulage Conditions.	Passengers	Car Mileage.
1913	Steam	25,011,569	—
1915	Steam until October 25, when Wimbledon section started ..	23,301,236	—
1916	Electrification nearly complete	29,361,917	12,355,404
1917	Electrification complete ..	32,869,316	16,089,563
1918	Electrification complete ..	40,376,731	15,452,352

in this country when railways generate their own electric power is about 40 per cent. It is probable that the electricity bought had about the same load factor.

The load factor for the electricity used for lighting and power is referred to later in its proper place. The total use of electricity by the 14 railways for traction, lighting and power in 1918 amounted to 517,000,000 kw.-hours and the annual one-hour load factor was 34 per cent.

When the war started, British railways were actually committed to the carrying out of additional electric traction and with it a certain amount of power and lighting which was stopped by the war. Had this work been carried out the estimated kilowatt-hours of electricity generated would have been 357,000,000 at an estimated load factor of 43 per cent.

But for the war the total electricity generated and bought by the 14 railways during 1918, including these commitments, would have been 875,000,000 kw.-hours at an annual one-hour load factor of 37 per cent.

For 1918 no complete returns of the electricity sold by public supply authorities in the United Kingdom are available. In 1914 it was 2,100,000,000 kw.-hours and in 1917 3,520,000,000 kw.-hours.* It has been estimated at 4,200,000,000 kw.-hours in 1918, it being of course understood that this figure is only for supply authorities and is exclusive of the quantities privately generated.

The 14 railways therefore actually used for all purposes in 1918 12½ per cent. of the quantity generated by supply authorities, and would have used 20 per cent. taking account of such part of it as would have been bought, supposing their actual commitments had not been stopped by the war.

Apart from the importance of the present railway load as compared with the whole load of the supply authorities, a proportion which is quite certain to increase as soon as railway policy is defined, I have insisted

* F. W. Carter: "Electrification of British Railways," *Electrical Review*, 1919, vol. lxxxv. pages 68 and 121.

* Journal I.E.E., 1919, vol.lvii, page 409.

on quoting a number of figures including load factors because there has been a tendency in some quarters to exaggerate the value of the railway load factor, which it will be seen both in actual fact and in estimate is in this country below 40 per cent. for the densest type of suburban service. The highest railway traction annual one-hour load factor in this country for one of the most dense electric services in the world—the London tube service—reaches 48 per cent. and is the same for traction as for lighting and power. But this value is altogether exceptional.

TABLE II.

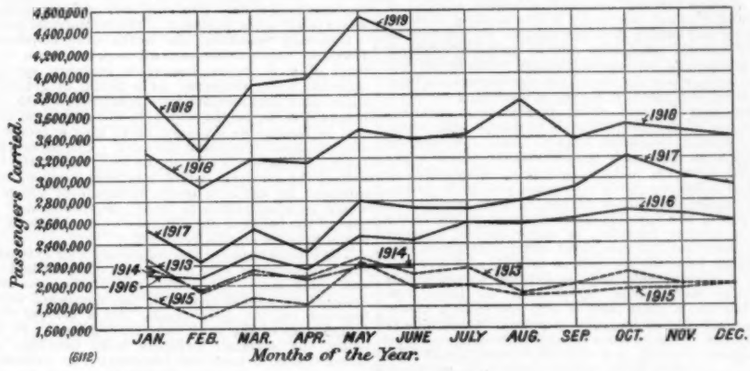
USE OF ELECTRICITY BY 14 LEADING BRITISH RAILWAYS FOR TRACTION, LIGHTING AND POWER DURING 1918.

Traction on 10 Railways.

Length of electrically-equipped route, miles	351
Equivalent length (including sidings) of single track, miles	834
Electricity generated by railways, kw.-hours	360,171,100
Maximum demand averaged over 1 hour (1-hour demand), kw.d.	99,380
Annual 1-hour load factor, per cent.	41·5
Electricity bought by railways, kw.-hours	39,076,000
Maximum 1-hour demand, kw.d.	23,450
Annual 1-hour load factor, per cent.	19
Total use of electricity for traction by 10 railways, kw.-hours	399,247,100
Maximum 1-hour demand, kw.d.	122,830
Annual 1-hour load factor, per cent.	37

Lighting and Power on 14 Railways.

Electricity generated by railways, kw.-hours	83,760,900
Maximum 1-hour demand, kw.d.	30,300
Annual 1-hour load factor, per cent.	32
Electricity bought by railways, kw.-hours	33,893,130
Maximum 1-hour demand, kw.d.	21,530
Annual 1-hour load factor, per cent.	18
Total use of electricity for lighting and power, kw.-hours	117,654,030
Maximum 1-hour demand, kw.d.	51,730
Annual 1-hour load factor per cent.	26



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Total Use of Electricity on 14 Railways for Traction, Lighting and Power.

Electricity generated and bought, kw.-hours	516,901,130
Maximum 1-hour demand, kw.d.	174,560
Annual 1-hour load factor, per cent.	34

Additional Commitments for Traction, Lighting and Power to have been Carried out but for the War.

Electricity generated and bought by 8 railways, kw.-hours	357,564,980
Maximum 1-hour demand, kw.d.	95,190
Annual 1-hour load factor, per cent.	43

Total Use of Electricity on 14 Railways for Traction, Lighting and Power, inclusive of Actual Commitments, to have been Carried out but for the War.

Electricity generated and bought by 14 railways, kw.-hours	874,466,110
Maximum 1 hour demand, kw.d.	269,750
Annual 1 hour load factor, per cent.	37

Seven Railways with Traction in Greater London.

Length of electrically-equipped route, miles	211
Equivalent length (including sidings) of single track, miles	556
Electricity generated and bought for traction, kw.-hours	340,247,160
Maximum 1-hour demand, kw.d.	100,340
Annual 1-hour load factor per cent.	38·5
Electricity generated and bought for lighting and power, kw.-hours	52,459,780
Maximum 1 hour demand, kw.d.	20,720
Annual 1 hour load factor, per cent.	29
Total use of electricity for traction, lighting and power, kw. hours	392,706,940
Maximum 1 hour demand, kw.d.	121,060
Annual 1-hour load factor, per cent.	37

Additional Commitments for Traction, Lighting and Power to have been Carried out but for the War.

Electricity generated and bought by 7 railways, kw.-hours	247,564,980
Maximum 1-hour demand, kw.d.	75,190
Annual 1-hour load factor, per cent.	37·5

Total Use of Electricity by 14 British Railways for Traction, Lighting and Power, including Actual Commitments to have been Carried out but for the War.

Electricity generated and bought by 14 railways, kw.-hours	874,466,110
Maximum 1-hour demand, kw.d.	269,750
Annual 1-hour load factor, per cent.	37

USE OF ELECTRICITY FOR EIGHT RAILROADS IN THE UNITED STATES FOR TRACTION, LIGHTING AND POWER DURING 1918.

Traction for Six Railroads. Four of them Steam Trunk Lines with some Electric Traction.

Length of electrically-equipped route, miles	1,413
Equivalent length of single track, miles	2,762
Electricity generated by railroads, kw.-hours	237,732,125
Maximum 1-hour demand, kw.d.	63,630
Annual 1-hour load factor, per cent.	43
Electricity bought by railroads, kw.-hours	239,847,678
Maximum 1 hour demand, kw.d.	55,150
Annual 1 hour load factor, per cent.	49
Total use of electricity for traction by six railroads, kw. hours	477,579,803
Maximum 1-hour demand, kw.d.	118,780
Annual 1-hour load factor, per cent.	46

Lighting and Power on Eight Railroads.

Electricity generated by railroads, kw.-hours	105,763,924
Maximum 1-hour demand, kw.d.	28,650
Annual 1-hour load factor, per cent.	42
Electricity bought by railroads, kw.-hours	58,024,000
Maximum 1-hour demand, kw.d.	14,445
Annual 1-hour load factor, per cent.	46
Total use of electricity for lighting and power, kw.-hours	163,787,924
Maximum 1-hour demand, kw.d.	43,005
Annual 1-hour load factor, per cent.	44

Total Use of Electricity on Eight Railroads for Traction, Lighting and Power.

Electricity generated and bought, kw.-hours.	641,367,727
Maximum 1-hour demand, kw.d.	161,785
Annual 1-hour load factor, per cent.	45

Diversity of many loads, of fairly good but different load factors, from one or more interconnected power stations where the individual units can be of greater output than would be possible in a power station devoted almost entirely to traction, will do more to cheapen electricity than the separate generating station for each railway. In London this result could have been achieved in the past by supplying the electrical needs of several railways from one station, but railway legislation made this quite impossible. So far as cheap electricity is concerned it would be an advantage for railways to be able to obtain electricity from power stations with diversity of load, generated by units of power large enough to reduce the capital invested to the lowest possible figure, since capital costs are half the generating costs and large turbo-generators are more economical than small ones.

But essential as cheap electricity is for railway electric traction, a cheap supply is only one and possibly not the most important requirement.

The locomotive working costs of a steam railway such as has been taken as typical when comparing passenger with goods and mineral working is one-third of the total traffic expenditure incurred in working the railway including locomotive repairs, maintenance and depreciation, and, of this third, coal and water which were in 1913 one-third now amount to about two-fifths. Roughly, electricity corresponds to and replaces steam-locomotive coal and water in cost, so that for main-line electrification electricity will figure as something of the order of 13 per cent. to 15 per cent. of the total traffic costs of running the railway.

To the railway what is of greater importance than the cost of electricity is security of supply, and the policy of the railway companies in building their own power stations and in wishing to keep those that they have built is chiefly for security of supply.

Railways work under statutory obligations, and before they depend on others than themselves for their supply of tractive power they must be sure that the supply will always be available, in the quantities they require at any moment, and in case of curtailment of supply, that the railway has the first consideration.

For railways taking a supply from other power stations than their own the geographical position of the latter relative to the railway is a matter of importance from the point of view of cost. The working-pressure transmission of a main-line railway is necessarily long and if, in addition, the substations are a long way from the power stations one of the advantages in cost of supply of the large common power stations may be lost in the transmission. Knowing that the capital charges form at least 50 per cent. of the cost of electricity, railways, like everyone else, are anxious to use stations equipped with the largest possible units of power so that the capital cost may be a minimum. In a recent paper Mr. J. S. Highfield* gave an analysis of present-day costs of stations and of generation which shows that a difference of 18*l.* in the capital cost per kilowatt of load in favour of a station capable of supplying 50,000 kw. above a station capable of supplying only 6,000 kw. of load was all wiped out by the cheapest possible high-pressure transmission at 33,000 volts in a distance of 15 miles with underground cables and in a distance of 30 miles with overhead cables.

The great capital cost of high-pressure transmission, coupled with the need for security, is the principal reason why railways have in the past preferred stations on their own property in spite of the disadvantages of smaller units of power and hence higher capital and working charges than in large common power stations.

I hope, however, that the working of the Electricity Act when it is passed may result in railways reaping the advantage of supplies from stations of low capital cost per kilowatt, possessing considerable diversity of load, so situated that they may be able to supply electricity cheaply at the substations, and so worked that the railway may have security of supply.

High-Pressure Direct-Current Electricity for Traction.—We have in this country examples both of high-pressure direct-current electric traction and of high-pressure single-phase electric traction. Both have been successful, and it is quite possible that under certain conditions as great economy may be obtained by the use of single-phase current provided that a single-phase supply is obtainable at a price which compensates for the higher efficiency and less cost of the direct-current motor on the train, and the increased losses in the return through the rails with alternating current. But in a majority of cases where economy was a first consideration careful estimates of both single-phase and high- or low-pressure direct-current traction have shown capital and working costs so decidedly in favour of direct current that those responsible for the expenditure had no hesitation in adopting the latter system.

Whether the railways are worked as a whole or as separate concerns, if main-line electrification is to be carried out it is necessary that an electric locomotive should work anywhere, and it is certainly desirable that one system should be adopted for the whole country for main line as apart from suburban traction. So far as our present knowledge goes the railways of the whole country would be more economically electrified by direct current than by alternating current.

The Ministry of Transport will doubtless review the whole situation before coming to a decision, but for the purposes of this address I propose to assume that any main-line electrification will be by means of high-pressure direct current.

Although there are instances to the contrary in Great Britain, it may be stated as a general rule for suburban service that it is not worth while to electrify for a service to be run by multiple-unit rolling stock unless a pair of tracks can be set apart wholly for the service. This condition obtains on a majority of the main-line railways which have suburban electric services and on one of them, where the suburban electric service interferes with the main line, a scheme is ready for extensive alterations to ensure the isolation of the suburban tracks. In general it is fair to assume that whatever system or voltage is in use for suburban services, this will not interfere at all or only to a limited extent with main-line electrification.

At present there is no need to fix a standard pressure or pressures for direct-current main-line working, nor has the matter yet been sufficiently discussed. Presently it will have to be fixed, but nothing has yet been done in the way of railway electrification which anticipates a decision or will prevent it being decided entirely on its merits. On their Manchester and Bury line the Lancashire and Yorkshire Railway have shown that the protected third rail designed by Sir John Aspinall can be used most successfully at 1,200 volts, and it is equally certain that, perhaps with some modification, it will be as successful at 1,500 volts. There are many places where overhead conductors are not desirable and others where they are not possible, and should this type of protected third rail be acceptable the maximum pressure at which it can be run will form the, or one, standard voltage.

The fullest consideration will then have to be given as to whether a pressure of, say, 1,500 volts is high enough for main-line electrification or if double this pressure will be needed for overhead equipment. Fortunately this decision will not have to be taken in a hurry, but if two pressures have to be used for main-line electrification, locomotives must be able to use both.

Suppose that a dozen contactors are wanted to control each pair of high-pressure direct-current motors at the lower pressure, then to enable the locomotives to work also at double this pressure some 30 contactors may be required.

Speed control by shunting the field goes far to remove perhaps the only disadvantage of the series motor, namely, that it has only one speed for each load. In favourable cases field control may reduce rheostatic losses during acceleration by as much as 50 per cent., and the additional running speeds obtainable are essential for main-line working.

The economy over the wearing away of wheel tyres and brake shoes by turning the series electric motor into a shunt-wound generator and returning a part of the energy otherwise lost in braking to the line by regenerative electric braking, is so obvious that it must always appeal to the engineer in spite of its difficulties. If it is required, then more contactors are needed, and should it be necessary to run a locomotive at two direct-current pressures one double the others, to employ shunt field regulation and to have regenerative braking, the 12 original contactors may be multiplied by four at least to give the necessary changes in the connections.

The cost and maintenance of so large a number of

* J. S. Highfield: "The Supply of electricity," Journal of the Royal Society of Arts, 1919, vol. lxvii, page 408.

contactors becomes a serious item, and until considerable experience has been obtained in their manufacture and maintenance they are the most likely source of failure.

Much consideration must be given to these and other matters before the standard pressures for direct-current main-line working can be settled, especially as to whether there shall be two pressures or only one.

Electrical Machinery for Handling Goods and Minerals.—The limitations of an address do not admit of dealing adequately with the subject of railway electrical machinery for handling all sorts of general merchandise, goods and minerals. The subject is almost as essentially a railway problem as electric traction, but only a few general remarks are possible.

Perhaps it will surprise many electrical engineers to see from the table given for the use of electricity by 14 British railways that in 1918 these railways required 118,000,000 kw.-hours for lighting and power: 29 per cent. of this was purchased and the annual one-hour load factor of this was 18 per cent. It will be appreciated how difficult it is to get the maximum one-hour demands correctly and this is probably too low. The annual one-hour load factor of the electricity generated by the railways for lighting and power was 32 per cent., varying from a minimum of 10 per cent. to a maximum of 48 per cent., and for the whole use generated and bought 26 per cent.

It is interesting to note from the American return that their load factor for lighting and power is appreciably higher and of the order of 45 per cent.

The proportion of the total kilowatt-hours used in railway docks and in goods stations and yards may not be very great, but at the present time much attention is being paid to the mechanical handling of goods.

General merchandise is carried by railways at rates which may or may not include collection and delivery by the railway. A large proportion of the general merchandise is both collected and delivered, and the general internal trade of the country has during very many years been built up on this method, resulting in the handling of a vast number of packages of all sorts, shapes, sizes and weights, each of which has to be checked in the goods station with its consignment note.

This demands a special staff of men in a goods station for examining each article. Any method of handling goods mechanically will not dispense with these men, and the faster goods are moved in the station the more men will be required to examine and check them, otherwise the speed of the handling machinery will depend on the speed of the checkers and callers off.

The whole railway methods of handling and hauling goods traffic have been built up gradually to suit the trader's requirements, and it must not be forgotten that, however much those requirements and the corresponding railway methods may be criticised, any complete system of mechanical handling must change the trader's methods of conducting his business, which is a far bigger matter than the design and installation of the mechanical appliances.

Under the present methods of working railway engineers have designed many schemes of conveyors and transporters which have been carefully considered, but few if any of them have been commercially acceptable.

In dealing, therefore, with general merchandise, where baskets of tomatoes or bags of potatoes may be followed by a ton of glass or a summer house, the mechanical appliances in goods stations consist generally of machinery for dealing with articles too heavy to be moved by hand. Fast travelling and traversing overhead electric cranes are ideal for this purpose since the goods platforms are left quite free. Without going into the reasons which usually require that in a goods station the roof stanchions which also support the crane gantry are spaced down the middle of a platform, it is becoming usual railway practice to attach a revolving jib to the bottom of the crab. This jib passes between the stanchions and is of such a length that the hook can command a siding or a cart road beyond the crane gantry on either side.

Until the entire habits of the traders are changed it does not seem possible to deal with general merchandise wholly by mechanical means, much as it would be to the advantage of the railways to do so. If it were possible the engineering problem with electrical machinery is quite straightforward. In a busy goods station in the west where two overhead cranes with underhung revolving jibs command the platforms, sidings and cart road and are generally in constant use day and night, careful checkings have shown that not more than 3 per cent. of the total weight of general merchandise handled in any one day is moved by the cranes. Where existing buildings do not allow head room for overhead cranes or runways, electric jib cranes either fixed, or travelling on a mono-rail, are the only lifting appliances available, but they are a very poor substitute for the overhead travelling crane.

Travelling appliances transfer the goods from wagon to cart, or *vice versa*, and the overhead travelling crane comes to the wagon wherever it is and goes to the cart wherever it is, or *vice versa*. Power appliances are also required to move the wagons themselves, either full or empty, and include electric wagon lifts where station and yard are at different levels, wagon traversers to transfer wagons to or from any siding, turntables and capstans, and examples of such electrical machinery are to be found all over the country. A great deal of trouble has been taken to render the Clyde type of electric capstan suitable for railways. This capstan has a steel wire rope fixed to a free barrel, the barrel being clutched to the motor through the reduction gearing only when current is applied. As compared with the usual type of capstan with a barrel permanently connected to the gearing and a hemp rope slipping on the barrel the saving in the cost of ropes is reduced by from 80 per cent. to 90 per cent., and this saving generally more than pays for the energy, which is reduced by 50 per cent., as also is the power.

In a goods yard the Goliath type of overhead travelling crane with a crab traversing along a bridge carried by a leg at or near each end and spanning one or more sidings and a cart road, is the most useful loading and unloading appliance. The whole structure travels up and down the yard and with electric capstans usually completes the yard equipment, though one or more jib cranes at points inaccessible to the traveller may also be necessary. Some very fine examples of Goliath electric cranes up to about 50 tons capacity are to be found in our railway yards.

When instead of general merchandise of all sorts of shapes, sizes and weights special goods of nearly uniform size and weight have to be dealt with in large quantities such as bales of cotton, cases or boxes of food or merchandise; coal; ores or other minerals and grain of all sorts the whole can be loaded, transferred and unloaded mechanically and electric machinery is by far the most suitable where the work cannot be done by gravity. Doubtless a great deal remains to be done in the application of conveying or transporting machinery for such purposes, and this especially applies to docks and harbours, although several railway docks are well equipped with electrical machinery.

For dealing rapidly with large quantities of material of about the same size and weight, it is possible to design a conveyor to meet almost any requirement, supplemented with apparatus for loading on to the conveyor and for receiving the conveyed material. Excellent examples of conveyors for dealing with coal, ore, china clay and other materials have been provided by railways at their docks or harbours, but much remains to be done.

General Use of Electricity by Railways.—In addition to a large electric lighting load and a certain amount of heating and cooking, electricity is also used by railways for opening and closing Scherzer bridges, for working all classes of general machinery and in most departments of their locomotive, carriage and wagon works for driving machine tools, while the use of the electric vehicle from a 5-ton lorry to a platform trolley is increasing rapidly.

A word may be said about electric train lighting, which is one of the most difficult problems with which railway electrical engineers have to deal. The electric apparatus is an automatic central station, which ought to run for a month without attention. Essentially it consists of a battery, with a dynamo and with control gear to render the output of the battery continuous. By the use of the variable-speed dynamo in which the voltage is roughly constant, or under control between a lower limit and the maximum obtainable speed, the power taken from the locomotive driving each dynamo through a carriage axle may be reduced to reasonable dimensions. Railwaymen have been so intent on getting the whole plant reliable that not enough attention has been paid to economy in power. Experiments with different dynamos show for the variable-speed type at high speeds a saving over the non-variable speed type of some 40 per cent. in the power taken from the locomotive for lighting.

Railway electrical engineering is a special branch of the profession demanding as much knowledge as can possibly be obtained of general railway conditions. An engineer requires all his youth for his engineering training and most of his manhood and middle age as well. He can usually only hope to pick up a smattering of general railway knowledge at second hand, and his success as a railway electrical engineer will largely depend upon his ability to absorb the knowledge and experience of his colleagues in other departments and from the railway staff in general. Railway electrical engineering, apart from telegraphs and telephones, is almost wholly a development of this century and it has undoubtedly proved its usefulness. But it depends as much on the personal character as on the professional ability of railway electrical engineers and on their honesty in solving the many problems which are set them by the management, as to whether railway electrical engineering serves the railways and through them the community at large, in the way in which it ought to serve both. I hope that this Institution will take a larger interest than it has done before in railway electrical engineers and that they in turn will in increasing numbers support this Institution.

Coal in British Malaya.—The discovery of coal near Kuala Lumpur, in the Federated Malay States, has proved a great benefit to the country during the past year or two. Last year's output was 168,000 tons, and it would have been higher had plant from England been obtainable. At a recent meeting of the Malayan Collieries, Limited, the chairman stated that the available tonnage of the Hawang coalfield could not be estimated with any degree of exactitude until boring plant to prove the measures at the lower depths was obtained; but he could safely say from their present data that sufficient coal is available for a life of thirty years, on an estimated output of 400,000 tons per annum. During the present financial year, the collieries are purchasing nearly 24,000*l.* worth of plant vitally necessary to increase their output; and in all, over 50,000*l.* will be spent in sinking a central shaft and to provide boilers, coal cutters and conveyors, brick kilns, electrical cables for pumps and coal cutters, improved haulage and screening plant, log-sawing machinery, another locomotive and a diamond drill. A briquetting plant is being introduced capable of turning out 100 tons per day.

ADMIRALTY HARBOUR, DOVER.*

By Maurice Fitzgerald Wilson, M.Inst.C.E.

The history of Dover dates from the Roman occupation, and from the earliest times the port was connected with the British Fleet. At a later date Dover became one of the famous confederation of the "Five Cinque Ports and two Ancient Towns," consisting of Hastings, Sandwich, Dover, Romney, Hythe, Winchelsea and Rye, which, in return for certain privileges, were required to provide a yearly quota of vessels for the King's use. In the thirteenth century the Cinque Ports were at their prime, and Dover supplied 21 ships for the King's service, being more than double the number furnished by any of the other ports, and this may be said to have laid the foundation of the British Navy.

In 1840 a Royal Commission was appointed to consider the question of harbours on the south-east coast, and eventually recommended Dover Bay as the most eligible position for such a harbour. Further Commissions were appointed in 1844 and 1845, and, as a result, in 1847 a commencement was made with the construction of the Admiralty Pier, and in 1871 this was practically completed for a length of 2,100 ft.

This single arm, however, not affording sufficient shelter, Messrs. Coode, Son and Matthews, in 1895 were instructed to proceed with the necessary survey, and prepare designs for the completion of the harbour, and in 1897 a contract for the whole of the work was let to Messrs. S. Pearson and Sons, Limited.

These works comprised:—

(*a*) An extension of the Admiralty Pier for a length of 2,000 ft.

(*b*) An eastern arm 3,320 ft. in length.

(*c*) A detached breakwater extending between the eastern arm and the Admiralty Pier, 4,212 ft. in length.

To the westward of the eastern arm a reclamation, 21 acres in extent, was formed by means of a sea wall 3,910 ft. in length, backed up by chalk filling derived from the adjoining cliffs. The total area of the harbour at low water is 610 acres, exclusive of the commercial harbour.

Generally speaking, the works were constructed of Portland cement-concrete, all exposed faces from the level of 3 ft. below low-water ordinary spring tides upwards being protected by a facing of granite. The three main breakwaters were constructed with concrete blocks 6 ft. in height and 7 ft. 6 in. wide on the face, and in lengths so arranged as to give a thorough and efficient bond throughout the work. The sea and harbour faces were battered 1 in. to the foot, except the harbour face of the east arm, which was built vertical, as it was intended for use as a quay, alongside of which vessels would lie when taking in stores, provisions, &c. In the case of the heads of the different works, blocks of special shape were, of course, required.

The foundations for the Admiralty Pier extension and south breakwater were laid upon a compact bed of flints and chalk marl. The outer end of the east arm was founded on similar material, the shoreward end being founded on the bare chalk. As a general rule the foundations of the work were carried from 4 ft. to 5 ft. below the surface. Parapets were provided on the seaward side of both the Admiralty Pier extension and the east arm. In the case of the south breakwater, which was not intended to be used as a quay, no parapet was provided, though provision is made for adding it if required.

The cope level of all the works is placed at 10 ft. above high water ordinary spring tides, the width at that level being 45 ft. in the case of the Admiralty Pier, 40 ft. for the south breakwater, and 47 ft. 6 in. for the east arm. The works were all finished off with a granite cope, backed by concrete pitching laid and grouted in cement. Boat steps, ladders and bollards were provided as required. The carrying out of the work naturally involved considerable organisation and extensive plant.

The ballast for the concrete was obtained partly from Sandwich and partly from Dungeness, and was conveyed to the works for the most part by rail, though a considerable portion of the material derived from Sandwich was carried by water. The cement was all manufactured in the Thames district, and was delivered by barge. The granite was chiefly obtained from quarries specially acquired and worked by the contractors at Gunnislake, in North Cornwall, being delivered at Dover by sea.

Two main work yards for the construction of the concrete blocks, &c., were provided, the west blockyard being formed on the foreshore to the westward of the Admiralty Pier, the east blockyard being formed upon the reclamation already described as lying to the eastward of the east arm. The concrete was mixed in Messent mixers of 1 cub. yard capacity and then deposited in the moulds. In the case of the east blockyard, special arrangements were made whereby the mixers were mounted on carriages which were travelled over the moulds upon an elevated railway, the concrete being dropped direct from the mixer into the mould. The whole of the machinery in this yard was worked electrically. The blocks after being moulded were left upon the floor for seven days before being lifted, after which they were removed and stacked ready for use. No block, however, was allowed in the work until at least one month after it had been made.

When ready for setting, the blocks were run out from the yard on block trucks, and set in the work by means of Goliath cranes travelling upon a staging spanning the work. The stagings consisted of clusters of piles placed in pairs, one on either side of the work, at 50 ft. intervals

* Abstract of a paper read at the meeting of the Institution of Civil Engineers on Tuesday, November 18. A fully illustrated account of the Admiralty Harbour, Dover, in its then condition, was given in our issue of October 15, 1909, page 501.

longitudinally. The piles were driven into the sea bed and securely braced. These pile clusters supported longitudinal girders, upon which were placed the service roads and roads carrying the goliath cranes already referred to.

The excavation of the sea bed was carried out by means of grabs worked from one of the goliath cranes upon the staging, this excavation being carried down to within 1 ft. of the final depth, the last foot being excavated by hand and carefully levelled by men working within a diving bell, which also was manipulated from the staging by means of a goliath crane. The beds having been carefully prepared, the blocks were then set by diver, the blocks being placed as closely as possible and without the use of mortar, and the work brought up to low water level. From low water upwards, the blocks were similarly set, but in a bed of cement mortar, the joints being grouted up solid and pointed.

The best progress was made in connection with the south breakwater, where 1,900 lineal ft. of foundation were constructed in one year, involving the setting of more than 13,000 blocks. In accomplishing this work, 1,300 lineal feet of staging, one 20-ton derricking crane, one 60-ton goliath crane, and four 40-ton goliath cranes were in constant use.

Considering the exposed position, the works were carried out with marked freedom from accident. In November, 1907, a large liner entering the harbour struck the recently completed western head of the south breakwater, removing bodily for a distance of 4 ft., a length of about 80 ft. of work, the full width of the breakwater, and 36 ft. in height. The total weight of concrete moved was about 10,000 tons. On other occasions some damage was done to the stagings by collisions or heavy seas.

The temporary lighting of the works and harbour approaches involved a considerable amount of thought and organisation, in order that the mail and other traffic of the port should not be interfered with. The arrangements in this respect, and also with regard to the permanent lighting of the harbour, were all carried out in accordance with the requirements of the Trinity House.

Extension of Term of Validity of French Patents.—Under a Law promulgated on October 8, and published in the *Journal Officiel* of October 10, the term of validity of French patents which had not expired prior to August 1, 1918, and patents issued or applied for subsequent to that date and before August 1, 1919, may now be extended on application, when it can be proved that the patentees or holders of the patent rights have not been able, owing to war conditions, to work their patents normally. The extensions of validity referred to are, however, subject to numerous conditions and formalities, particulars of which will be found in the *Journal Officiel* of October 10. The British Chamber of Commerce, Paris, however, strongly recommend any of their members who are desirous of availing themselves of the extension referred to, to take the matter up with a competent firm of Franco-British patent lawyers to steer them through the technical and legal intricacies of the procedure.

Financial Legislation in Italy.—According to *The Board of Trade Journal*, recent articles appearing in the Italian press show that the financial measures proposed by the Italian Government are meeting with strong opposition. By what is called in one journal a "providential indiscretion," the terms of the provisional tariff reform were apparently made public prematurely. This gave the industrial interests time to marshal their forces, and the General Confederation has issued a manifesto to the effect that the proposed new duties, which on an average are about 50 per cent. higher than those previously existing, should be increased by an additional 100 per cent. and should be extended to all articles and not confined to those usually imported from the Central Powers. The scheme for a forced loan is very strongly criticised, especially on the ground that the rules for valuation of real property will work most unfairly. It is possible that the whole matter will be reserved for consideration in detail by the new parliament which is now being elected.

Certified Engineers in Queensland.—Under new local government legislation which is being introduced into Queensland, there are regulations affecting the certification and employment by local authorities of authorised engineers. The Governor-in-Council may, by the regulations, provide for:—(*a*) The employment of certificated engineers; (*b*) for the circumstances and conditions under which exemptions from the employment of certificated engineers may be granted to local authorities; (*c*) the qualifications necessary for the grant of certificates; (*d*) the conditions under which two or more local authorities may join in the appointment of the same certificated engineer; (*e*) the classes of works upon which the local authority shall employ a certificated engineer. With regard to the proposed termination of employment of any clerk or engineer, the local authority shall either order an inquiry or suspend the officer. If suspended, the local authority must state the reason for his suspension. The officer may then apply for an inquiry, and if an inquiry is asked for, it must be held by some person appointed by, but not a member of, a local authority. If the local authority and the officer concerned so agree, the inquiry may be held in private, otherwise it shall be public. The person holding the inquiry reports to the local authority, and the report must be read in open meeting. Where an inquiry is ordered, no decision shall be given by the local authority until after the reading of the report.

CATALOGUES.

Electric Accumulators.—A catalogue from Batteries Limited, Redditch, states that the company has obtained the patent rights of a nickel-iron-alkaline accumulator. The electrolyte consists chiefly of a solution of potassium hydrate in distilled water. Exceptional compactness and durability are claimed for these accumulators, which are suitable for all usual purposes.

Concrete Reinforcement.—A system of making up reinforcement for roads, walls, floors, barges, &c., described in a catalogue of the Walker-Weston Company, Limited, 7, Wormwood-street, E.C. 2, is worth attention. The bars and rods may be delivered straight or in coils and cut up and laced together on the site of the work. A simple cutting machine and pegged tables are the only plant necessary.

Heat Treatment.—A number of tests of iron, mild steel and hardening steels after various heat treatments are given in a leaflet from Automatic and Electric Furnaces, Limited, 281, Grays Inn-road, W.C. 1. The steel that proved hardest in the annealed state, contained 10·6 per cent. chromium, and was found to cut easily in the lathe. The leaflet gives a clue to the best methods of heat treating the various steels.

Bearings.—A pedestal bracket bearing for alternating-current induction motors is the subject of a catalogue, issued by the British Westinghouse Company, Limited, Trafford-park, Manchester. The smallness of the air gaps (as compared with direct current motors) demands a very fine adjustment of the rotor within the starter, and this is effected by shim plates under the bearing, and keys at the sides.

Mine Signalling.—A system of signalling from the bottom and top of mine shafts to the man in charge of the winding engine, is described in a catalogue from Messrs. Siemens Brothers and Co., Limited, of Woolwich and Palace Place Mansions, Kensington Court, W. 8. In addition to the ordinary signal a visual signal is automatically shown and remains until complied with. The apparatus is specially made to comply with the provisions of the Coal Mines Act, 1914.

Clutches.—Plate clutches, dry and lubricated, are the subject of a special catalogue issued by the Herbert Frood Company, Limited, Chapel-en-le-Frith, Derbyshire. There are several excellent line illustrations and some useful technical text. The Ferodo fabric linings made by the company are stocked in over 70 sizes, from about 4¼ in. to 15 in. diameter, 3½ in. to 10 in. bore, and under $\frac{1}{16}$ in. to over ¼ in. thick. The catalogue will be useful as a reference book of technical information on this part of the subject of plate clutches.

Gas Welding.—Some useful practical notes on the O-A welding system appear in a little periodical publication issued by the Davis-Bournonville Company, Jersey City, U.S.A. There is also a description of a machine for trepanning holes in plates, round or oval shapes being produced by a cam guided blowpipe. The paper, by Commander Knox, describing the work of repairing the broken cylinders of three German ships, the Neckar, Rhine and Bulgaria, is reprinted.

Pneumatic Tools.—Air-driven hand machines for riveting, chipping, scaling, metal and wood drilling, ramming and grinding, are very fully illustrated and described in a special catalogue of 98 pages issued by the Consolidated Pneumatic Tool Company, Limited, Fraserburgh, and 106, Piccadilly, W. 1. All the necessary hose connections are included, and there are drilling and chipping tools for use under water. Full particulars of sizes and capacities are stated for each tool.

Oil Pipe Lines.—The time, labour, &c., of laying long pipe lines are stated in a catalogue from Messrs. Sanderson and Porter, New York, who carry out contracts of this kind. The work of laying a line of 555 miles total length is described; 130 miles of 6-in. pipe and 450 miles of 10-in. pipe were used, to convey oil at the rates of 5,500 barrels and 24,000 barrels per day respectively. The best day's work (9 hours) was the laying of 11,740 ft. of 6-in. pipe by a company of 26 men; 8,200 ft. of 10-in. pipe were laid in 9 hours by 36 men. In both cases over 20 bends had to be made. The information is given in considerable detail.

X-Ray Apparatus.—The application of X-ray photography to surgical and dental work now creates a special branch of apparatus manufacture. The "Röntgenologist" gets instruction from manufacturers' catalogues in terms which plain people cannot easily understand; but he is like the rest of us on one point—he requires to be continually and vigorously cautioned against buying the cheapest articles on the market. The catalogue issued by the Kelley-Koett Manufacturing Company, Covington, Ky., U.S.A., shows a considerable range of apparatus, clearly illustrated and stating reasons for the special construction favoured by this firm.

Cutting Tools.—Inserted cutter bits, long used in boring bars, are now largely employed for turning and planing tools, especially since high-speed steel became common. Amongst the many tool holders is that made by the Lovejoy Tool Company, U.S.A., who make a bit with cross serrations on the shank fitting into grooves on the locking piece; with a wedge pin to tighten the hold. A good range of sizes and holders are made, and the bits are supplied in high-speed steel. The catalogue comes from the sole agents for the British Isles, the Selby Engineering Company, Limited, 6, Broad-street Place, London, E.C.

Measuring Gauge.—Many excellent mechanics strongly prefer the measuring instrument proper to the "go" and "not go" gauges, because they like to know how far the work is from the desired size at each trial. They have then more confidence in setting the depth of the next cut. Hence the popularity of the micrometer over the gauges. The opinions and ideas of workmen who take a keen interest in their work, and there are plenty of such men in spite of all kinds of agitations, should be considered carefully and respectfully. This is what Messrs. Tuck and Blakemore, Coventry, have done in introducing their micro-gauge, as the text of their interesting catalogue shows. The instrument is fixed at the exact size, and the thimble turned in either direction, the plus or minus size being indicated on a dial which revolves with the thimble. The dial turns a little less than a whole revolution. The total range of measurement of the limits is three-hundredths of an inch, and this is divided in two directions from a zero mark—zero being the exact size to be attained. Various dials, easily read in thousandths and half-thousandths, with unequal plus and minus limits, and also metrical graduations, are supplied. Hand and bench forms are shown.

Agricultural Machinery.—The Agricultural and General Engineers, Limited, sends a catalogue, or statement of policy, announcing itself very frankly as a "combine." The combined firms are Messrs. Aveling and Porter, Limited, Rochester; E. H. Bentall and Co., Limited, Heybridge; Blackstone and Co., Limited, Stamford; Richard Garrett and Sons, Limited, Leiston; and James and Frederick Howard, Limited, Bedford. The combination really amounts to the formation of a "general staff" for directing purposes apart from actual production, as each firm retains its own chief and works staff. It is noteworthy that while many of our engineering firms are compelled by world competition to combined business operations they have still found a way of preserving their individuality. These firms make practically all the engines and machinery necessary in agriculture, as well as in the seed and flour-dressing industries which work in close contact with agriculture. The statement inspires confidence in their power to advance British engineering in the markets of the world. The offices will be at Central House, Kingsway, W.C. 2, from about the end of this year, and are now temporarily at 50, Pall Mall, S.W. 1.

Motors and Dynamos.—A catalogue of direct-current machines, dynamos and motors, made by Messrs. J. H. Holmes and Co., Portland-road, Newcastle-on-Tyne, extends to 60 pages of concise description. The details of output, speeds, pressures, dimensions, prices, &c., are very completely presented in clear type tables. The series includes two-pole and four-pole motors; two-pole and four-pole dynamos; six-pole and eight-pole motors and dynamos; and dynamos for battery charging and for welding and cinematographs; finally, four-pole dynamos direct coupled to vertical steam or petrol engines. The motors are in a very full range of sizes from ¼ brake horse-power to 800 brake horse-power, and the dynamos from under ½ kw. to over 600 kw. Both protected and enclosed ventilated types are made. The machines are adapted to suit all conditions of supply and work and the parts are made on interchangeable methods. The catalogue is an excellent proof of how thoroughly British engineers are meeting the most varied needs of the power consumer. Accessory plant such as switchgear, starters, &c., are supplied as required. Messrs. Holmes have specialised in electrical machinery since 1883 and offer experienced technical advice to users of their machines.

Aerial Transport.—A booklet issued by the English Electric Company, Limited, Thornbury, Bradford, compares the cost of transport by flying boat, motor lorry and steamship. The two cases compared are: (1) A flying boat and motor lorry following a river route for 150 miles, and (2) a flying boat and steamship crossing a sea 800 miles wide. Although there are some interesting figures which give a value to the book they are not reduced to terms of money, and "cost" means money. It is doubtful if the basis of ton-miles per man-hour is of more than very limited theoretical value in three different types of transport. At the best it is an arithmetical abstraction, and must be used with much skill of interpretation even in comparing one railway with another in the same country. Three really important facts stated in the booklet are that the flying boat will carry a burden of 1½ tons 150 miles in less than 2 hours, while the lorry can only do the task in 20 hours; on the other hand, the lorry will carry an object of 2 tons to 5 tons weight, which the boat cannot carry at all. Further, the steamship built to carry 220 passengers will easily carry both the boat and the lorry and their loads in addition to its own, at a trifling extra cost. All this is lost in the ton-mile per man-hour term. The desirable thing is to adapt the aerial vehicle to some peculiar tasks for which other vehicles are not adaptable, and then to lower the cost as much as may be. The idea of the air vehicle actually competing with other means of transport is quite outside of discussion amongst engineers. The booklet will help to turn this discussion into a practical channel.

The Wireless Society of London.—The next general meeting of this society has been arranged to take place at the Institution of Civil Engineers, Great George-street, Westminster, on Wednesday, November 26, at 6 p.m. Mr. J. Scott Taggart, M.C., A.M.I.R.E. will read a paper on "A System for the Reception of Continuous Waves," after which the meeting will be open for discussion. Mr. Scott-Taggart is head of the valve department of Messrs. Ediswan, Limited. The Secretary of the Wireless Society, Mr. Leslie McMichael, announces his change of address to 32, Quex-road, West Hampstead; all communications should be sent to this address after the 23rd inst.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Name, &c., of the Communicators are given in italics.

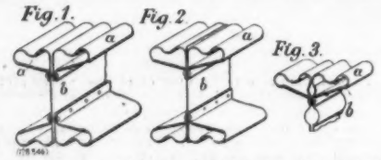
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

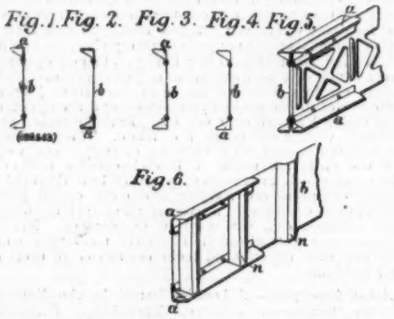
AERONAUTICS.

128,846. E. E. Brown, Westminster, London, and D. J. Mooney, Westminster, London. Aircraft. (7 *Figs.*) December 14, 1918.—Metal girders for aircraft of the type having triangular flanges united by a web as set out in the parent



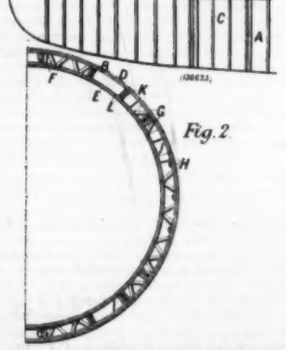
specification, No. 128,663, of which this is a patent of addition, have the flanges, and if desired the webs also, provided with corrugations. One or more web pieces *b*, corrugated or straight, may be employed either in one piece with one upper and one lower flange *a*, or riveted thereto. Figs. 1, 2 and 3 show typical forms. (*Sealed.*)

128,663. E. E. Brown, Westminster, London, and D. J. Mooney, Westminster, London. Aircraft. (9 *Figs.*) August 29, 1917.—Struts, spars, girders, &c., for aircraft wings, fuselages, &c., are made of thin steel or aluminium alloy and comprise members composed of webs *b* and triangular flanges *a* bent and secured as shown in Figs. 1 to 4, the members being used singly or combined together in pairs. The webs may be ribbed and perforated as shown in Fig. 5, which also shows two members



similar to Fig. 1 secured back to back. Two members may be spaced apart by continuous upper and lower plates overlapping the flanges; or discontinuous plates may be used integral with vertical pieces extending between the webs. Cross-ribs may be secured to the members by saddle pieces. Fig. 6 shows a modified member having vertical ribs *n* stamped in the web, either the rib *n* or the flange *a* being cut away where they meet. (*Sealed.*)

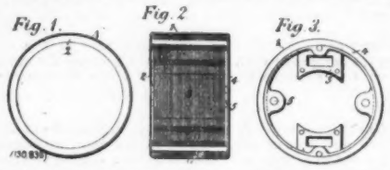
130,623. W. G. Tarrant, Byfleet. Aeroplane Fuselages. (3 *Figs.*) November 27, 1917.—This invention relates to aeroplane fuselages of the type built up of circular ribs and longerons. According to this invention, the fuselage framing comprises a



series of annular or circular girders or main ribs A, A, and longitudinal girders or longerons B built into them, the circular girders or ribs being suitably spaced apart according to the size of the fuselage and intersecting the longerons at right angles, while the longerons are built up of longitudinal members with cross braces or struts fixed between them. Between the circular girders or main ribs A, A, former ribs C are fixed, and the whole is enclosed in a casing or sheathing of two, three or four-ply wood, glued and screwed to the longerons and rings, the whole forming an exceedingly strong and economical structure. Each of the girders A is constructed as shown in Fig. 2, of two wooden braces F. G are radial braces connected to the rings D, E, and arranged one on each side of a longeron, where it passes through a girder. H are light longerons connected to the outer ring D. J are filling pieces inserted between the rings D, E. Packing pieces equal in thickness to the rings D are secured to the outer faces of the longerons between each ring and the next so as to make a flush surface. The girders and former ribs are, of course, made of varying diameter to give the necessary stream-line to the fuselage contour. The longerons are built up of longitudinal members K connected by cross-braces. (*Accepted August* 20, 1919.)

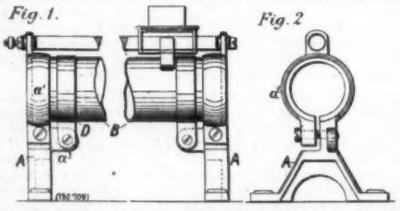
ELECTRICAL APPARATUS.

130,835. George Kent, Limited, London, and A. H. Avery, Tunbridge Wells. Field Magnets. (5 *Figs.*) September 24, 1918.—According to this invention, the stampings forming the field magnets are encased in a metal tube and held therein by flanging the tube. A thin seamless drawn metal tube having an inside diameter large enough to accommodate the stampings with a thin layer of insulating material outside them, is first spun, pressed, or otherwise formed with a small flange at one end and cut to the required length. The iron stampings are then assembled into their positions, with any necessary insulation, pressed firmly together and the other end of the casing or tube then flanged down, thus gripping the stampings



firmly and without twist or distortion. This ensures a sound, mechanical, self-supporting construction, having truly parallel opposite faces for attachment to the end bearing brackets, also a smooth external surface suitable for stove-enamelling, plating or any other kind of machine finish. 1 is the seamless metal tube formed with a small flange 2 at one end. In the tube 1 are assembled the stampings 3, with any necessary insulation; the stampings 3 are then pressed firmly together, and the other end of the tube 1 is flanged down as shown at 4, thus gripping the stampings 3 firmly and without twist or distortion. Holes 5 in lugs on end rings are provided for the passage of bolts to secure the end bearing brackets which are not shown. (*Accepted August* 20, 1919.)

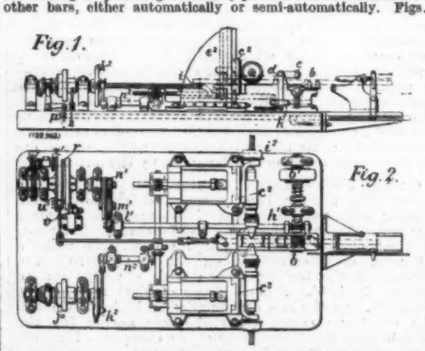
130,909. L. F. A. Forgarty, Willesden Green, London, and C. T. Lehmann, London. Electrical Resistances. (6 *Figs.*) February 19, 1919.—This invention has relation to electrical resistances of the kind known as the "tubular type." A represents the base or foot of the brackets or supports and B the usual insulated tube upon which the helical coil (not shown) is wound. The part a^1 of each bracket, in which the ends of the tube B are supported, is made in one with the other part or base or foot, like a split ring, and provided with an adjusting or tightening screw, so that when the tube is placed in position



by tightening up these screws the ends of the tube are clamped or tightly held in position, and should this clamping part of the brackets become loose through repeated expansion and contraction of the parts, they can be easily and readily tightened up by the screws. Formed with or fixed to the rigid part or base or foot of each bracket, is a lug or projection a^3, to which the bands D, insulated therefrom, are secured by the screws that tighten them around the tube to hold the ends of the coil. It will thus be seen as these bands D are rigidly held in position, that it is impossible for the helical coil to become displaced or move through any cause. (*Accepted August* 20, 1919.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

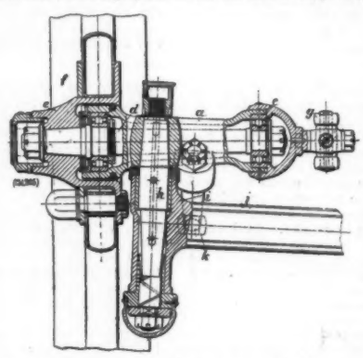
128,968. Sir J. McKechnie, Barrow-in-Furness, and B. N. Wallis, Grange-over-Sands. Drilling or Punching Machines. (12 *Figs.*) September 4, 1917.—Relates to means for drilling or punching accurately-pitched holes in channel or other bars, either automatically or semi-automatically. Figs.



1 and 2 show a machine for drilling a channel bar having two opposite drill heads which are angularly adjustable on slides e^2, vertically adjustable on brackets e^3, which again are transversely adjustable on the machine bed. The work is fed between a driven roller *b* and a pressure roller *c*. Before introducing the work, the roller *c* is raised by a hand lever *h* acting through a cam on a lever *d*. The work is then pushed forward against a stop *i* adjusted to suit the distance of the first holes from the end of the bar. The hand lever is then actuated to lower the roller *c*. The feed roller is driven through a friction gear by the belt pulley b^1, which also drives through a shaft k^1 and the gear l_1, s^3, s^4, a pitch plate *r* or an equivalent device. On this plate are adjusted dogs which, when they strike a stop *v*, Fig. 2, arrest the movement of the pitch plate and the feed roller. The pitch plate is driven from the gear s^4 by a sun-and-planet motion, the planets being carried by a disc to which movement in either direction can be given to vary the pitch by pins s^5 carried by the pitch plate acting on a wheel z^1, which, through a reversing gear, rotates the planet disc. Each drill spindle is driven by a belt pulley c^2 and fed to a drill hole, and is then withdrawn by rack-and-pinion gear driven by an oscillating shaft n^2. This shaft receives its oscillating movement from a crank disc k^2 driven by a one-revolution clutch from a belt pulley j^0. After the work has been introduced, the attendant operates a lever p^4 to put in gear the one-revolution clutch, so that the first holes are bored. As the disc k^2 completes its revolution, a cam on its shaft removes the work stop and the stop from the dog on the pitch plate, which then, with the feed roller, is driven by the friction gear to feed the work until the next dog on the pitch plate abuts against the stop *v*, which has been replaced meanwhile. Just before the stop comes into action, a projection on the pitch plate actuates a lever which throws in the one-revolution clutch to bore the next set of holes. (*Sealed.*)

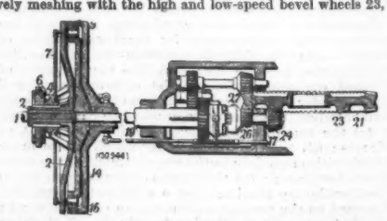
MOTOR ROAD VEHICLES.

131,205. W. Thomas, Soho, Birmingham, and E. G. Wrigley and Co., Limited, Soho, Birmingham. Steering Wheels. (3 *Figs.*) October 19, 1918.—This invention relates to bearings or mountings for the steering wheels of motor road vehicles, of the type in which a sleeve is provided with a wheel axle bearing at each end, and a steering pivot stem is formed with or secured to the said sleeve at a position between the said bearings. The invention consists of the improved means hereinafter described for connecting and operating the pair of bearing sleeves arranged with the two front or steering wheels of a motor vehicle. A sleeve *a* is suitably enlarged at each end to accommodate a ring of bearing balls or rollers *b* and *c*, one of the rings *b* being preferably larger than the other *c*. The bearings carry a wheel axle *d* which projects at one end and is adapted for the



attachment thereto of the hub *e* of the road wheel *f*. Preferably the hub is cupped to fit freely over the adjacent end of the bearing sleeve. The opposite end of the sleeve is closed. On this end of one of the sleeves is formed or attached a connection *g* for the link actuated by the steering mechanism. At a position between the bearings and rather nearer the outer or larger bearing is formed with or secured to the sleeve a pivot stem *h* which fits a bearing *i* on the axle bed *j* of the chassis. On the sleeve is also provided an attachment *k* for the usual coupling rod *l* by which the two wheels are connected. From the foregoing it will be seen that the coupling of the two bearings of the front or steering wheels of a motor vehicle is effected by the provision of an attachment *k* on each of the sleeve parts, to which attachment is secured the usual coupling rod, and steering is effected through the medium of the connection *g* on one end of one of the sleeves. (*Accepted August* 27, 1919.)

130,944. J. F. Wollesen, Lockwood, California, U.S.A. Variable-Speed and Reversing Gearing. (6 *Figs.*) April 28, 1919.—This invention relates to variable-speed and reversing gearing of the type in which a number of concentric bevel wheels on the transversely-arranged driven member are engaged by corresponding bevel pinions mounted upon and adapted to be selectively connected to the longitudinal driving shaft. According to the present invention, the longitudinal shaft is composed of inner and outer members 17, 19, concentric with and revoluble in relation to one another, these members being selectively engageable by frictional clutch mechanism at the driving end, and carrying at their further ends bevel pinions 24, 26, respectively meshing with the high and low-speed bevel wheels 23, 21,



upon the driven member. The frictional clutch mechanism comprises concentric annular flanges 14, 16, respectively connected to the two shaft members, and a disc 2 secured upon the driving shaft 1 and carrying shoes 9, which project between the annular flanges and may be moved radially inwards or outwards to engage either flange and so transmit power to either member of the longitudinal shaft. These shoes are controlled by cams 6 operated by connecting rods 7 from a shifting device 4 mounted on the hub of the driving disc. The bevel pinion 24 on the inner shaft member 17 is rigidly secured thereto, but the pinion 26 on the outer shaft member or sleeve 19 is revoluble thereon, being coupled by means of a sliding jaw clutch 27 when the low speed is in operation, and the countershaft operating the reverse gear being engaged when desired by an opposite motion of this jaw clutch. (*Accepted August* 20, 1919.)